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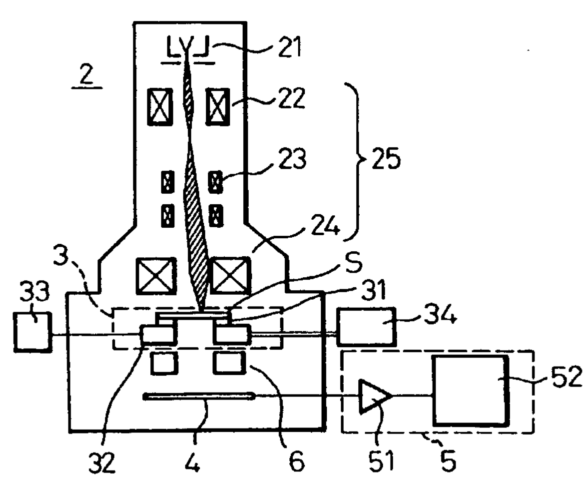
(54) Pattern inspection apparatus and electron beam apparatus.

(57) A pattern inspection apparatus is designed to quickly and accurately perform an inspection of an inspecting sample, such as masks, wafers or so forth by irradiating electron beams onto the inspection sample and detecting a secondary electron or a backscattered electron reflected from the surface of the inspecting sample or a transmission electron passing through the inspection sample. The pattern inspection apparatus includes an electron beam generating means including at least one electron gun for generating at least one electron beam irradiating on the surface of the inspecting sample, a movable means for supporting the inspecting sample, a detecting means including a plurality of electron detecting elements for detecting electrons containing information related to the construction of the inspection sample and a detection signal processing means for processing simultaneously or in parallel formation the outputs of the electron detecting elements of the detecting means. Also, when a plurality of electron beams are used for simultaneous irradiation of the inspecting sample, the pattern inspection apparatus is provided a mechanism for avoiding interference of a reflected beam of the adjacent electron beam.

Fig. 2



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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a pattern inspection apparatus. More specifically, the invention relates to a pattern inspection apparatus for performing an inspection of a mask pattern, such as a mask, reticule and so forth to be used in exposure technology for transferring a fine circuit pattern on a semiconductor substrate or a fine circuit pattern formed on a wafer. Further specifically, the invention relates to a pattern inspection apparatus for inspecting a pattern configuration or a defect or an error in the pattern configuration of inspection samples, such as a mask to be used for X-ray exposure technology for transferring a fine circuit pattern and so forth on the semiconductor substrate employing an X-ray including a synchrotron radiation beam (SOR), a wafer, in which the fine circuit pattern is formed on the semiconductor substrate or a mask, reticule or so forth to be used in light exposure technology for transferring a fine circuit pattern to the semiconductor substrate employing an ultra-violet light as a light source.

2. Description of the Related Art

Conventionally, in order to transfer the fine circuit pattern onto the semiconductor substrates, the ultraviolet light is used as a light source. Normally, a mask containing patterns for several chips are employed to perform a transfer of a compressed pattern by periodically shifting the transfer position on the wafer in a step-and-repeat manner, on a large diameter wafer. At this time, for defect inspection of the wafer pattern for checking foreign matter or a defect on the mask pattern or for defect inspection of the foreign matter on the wafer or the wafer pattern, an optical method employing an optical micrograph is frequently used. However, according to an increasing density of the fine circuit pattern, it has become necessary to provide a light source with a shorter wave length for use in the wafer pattern inspection. In the conventional light source employing the conventional optical system, the resolution can not be improved because of a specific diffraction limit to make it difficult to detect a substantially small defect.

As a solution, the development of inspection technology employing an electron beam has progressed.

Namely, according to an increasing density of circuit patterns, X-ray exposure technology employing an X-ray containing synchrotron radiation beam (SOR) is regarded as one of the important next age transfer technologies. Simultaneously, it is becoming necessary to shorten the wavelength for the light source to be used for inspection of the X-ray mask.

In the prior art, upon inspection of the mask as set forth above, reticule, a wafer on which a specific pattern is formed, or so forth, the subject for inspection is foreign matter (particle) adhering on the surface of the mask, reticule, the wafer or so forth, or a defect of the pattern as shown in Fig. 18, such as a protrusion 201, a intrusion 202, a break 203, a bridge contact 204, a pin spot 205, pin hole 206 and so forth. The generally required sensitivity is, for example, in the case of foreign matter,

for bare wafer: (pattern dimension) x 1/7 to 1/5
for patterned wafer: (pattern dimension) x 1
for reticule or mask: transfer limit.

On the other hand, in the case of a pattern defect, the required sensitivity level is generally (line width) x 1/2.

However, with an increase in the pattern density and an increase in package density, higher sensitivity becomes necessary. However, in the case of the inspection process employing the light beam, there is a limit for thinning the light beam. Even when the wavelength is shortened, the highest possible sensitivity of the visual light is 0.25 μm. Therefore, the size of the device to be inspected is limited to 4M to 16M DRAM. On the other hand, even when an ultra-violet light beam is employed, the maximum possible sensitivity to be achieved is 0.15 μm. In this case, the size of the device to be inspected can be up to 64M DRAM. Therefore, it is difficult to effect an inspection for 256M DRAM or next age devices achieving a further reduced size and greater packing density, such as 1G DRAM.

Therefore, a method employing an electron beam in place of the light beam has been considered.

In the method employing the electron beam, fewer problems will result by increasing the pattern density and thus can permit the fabrication of higher density patterns than with a light beam.

However, in such prior art, there is a problem in that the information detected by a detecting means is processed independently in a time sequence in a detecting process and therefore, a relatively long data processing period is required.

In addition, as set forth above, according to an increase of circuit pattern density and an increase of package density, the amount of data to be processed in pattern inspection of the device is naturally increased. Therefore, it is required to provide a greater capacity for accepting data to be arithmetically processed.

For example, there is a tendency to require a process for $(1\ cm/0.1\ um)^2 = 100\ M\ pixel/cm^2$, 8" wafer, 31G pixel/wafer.

In contrast, according to an increase of the density of the circuit pattern, the size of the pattern unit for processing to check whether a defect is present or not becomes small. In addition, the capacity of the individual chip is increased. Therefore, according to an increase of the circuit pattern density, the information amount to be processed for inspection rapidly increases. In the conventional electron beam system, a

single electron beam is scanned on the mask in order to detect the generated secondary electron, the backscattered electron or transmitted electron. Therefore, a signal from the irradiating region of the electron beam with high convergence for detecting very small defects, is generated continuously in a time sequence. This creates a long time period in the transmission of the image information to a signal processing system. Therefore, even when the process speed in the signal processing system is increased, it still requires a long time period for inspection.

Namely, in the patten inspection employing the electron beam, the electron beam is irradiated on the inspecting sample, such as a mask, wafer or so forth and is scanned in order to introduce the electron flow generated from the irradiating portion to the detecting portion. The electron current introduced into the detecting portion contains configuration information relating to the pattern. From the signal formed by the electron flow, the pattern information can be obtained in a time sequence.

As the electron flow to be introduced into the detecting portion from the irradiating portion of the inspecting sample, a secondary electron variable of incident direction to the detecting portion depending upon the configuration of the inspection sample, a backscattered electron variable of an amount depending upon the material and configuration of the inspecting sample or a transmitted electron variable of a passing amount depending upon the pattern when the inspecting sample is a thin film mask, an X ray mask or so forth. With respective electrons, the plane configuration and three dimensional configuration, such as projection and recess and so forth, can be recognized.

However, as set forth above, the method employing the electron beam contains a problem in that the inspection speed is slow requiring a long process period.

SUMMARY OF THE INVENTION

It is an object of the preset invention to solve the problems in the prior art and thus provide a pattern inspection apparatus that can detect a defect in a circuit pattern on an inspecting sample, such as a mask, wafer or so forth, by scanning at least one electron beam on the inspecting sample and using a secondary electron or backscattered electron from the inspecting sample or an electron transmitting the sample with high sensitivity and high process speed, and thus can be adapted for larger capacity of information and higher processing speed for processing the pattern of the mask, wafer or so forth with a high density circuit pattern and high package density.

According to the present invention, there is provided a pattern inspection apparatus which comprises:

electron beam generating means including an electron gun for generating at least one electron beam accelerated and converged into a predetermined diameter and irradiating an inspecting sample;

movable support means for supporting the inspecting sample;

detecting means including a plurality of electron detecting elements arranged on a plane for detecting electron containing construction of the inspecting sample; and

signal processing means for processing information output from respective electron detecting elements of the detecting means simultaneously or in parallel formation.

With the construction set forth above, the present invention can detect a fine pattern on the mask, wafer or so forth with high accuracy. Also, according to the present invention, since the electron transmitting the sample or generated from the surface of the sample, which contains information of the predetermined portion of the pattern, can be processed simultaneously or in parallel formation to contribute to the shortening of the process period.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more fully understood from the detailed description given herebelow and from the accompanying drawings of the preferred embodiments of the invention, which, however, should not be taken to be limitative to the invention but are for explanation and understanding only.

In the drawings:

Figs. 1(a) and 1(b) are schematic block diagram showing practical embodiments of a pattern inspection apparatus according to the present invention;

Fig. 2 is a fragmentary section of one embodiment of the pattern inspection apparatus of the invention;

Figs. 3(a) to 3(c) are illustrations showing a principal of pattern inspection method when the embodiment of the pattern inspection apparatus of the invention illustrated in Fig. 2 is employed;

Fig. 4 is an illustration showing the principal of pattern inspection when the embodiment of the pattern inspection device according to the invention and illustrated in Fig. 2 is employed;

Fig. 5 is a schematic illustration showing construction of a detection means 4 to be employed in the pattern inspection apparatus according to the invention;

Fig. 6 is a schematic illustration of another construction of a detection means 4 to be employed in the pattern inspection apparatus according to the invention;

Fig. 7 shows an example of a construction of a movable support means 3 to be employed in the pattern inspection apparatus of the invention;
Fig. 8 shows an example of an electron beam generating means 2 to be employed in the pattern inspection apparatus of the invention;
Fig. 9 is an illustration showing a irradiating condition of the electron beam when the electron beam generating means 2 of Fig. 8 is employed;
Fig. 10 is an illustration showing another example of the electron beam generating means 2 to be employed in the pattern inspection apparatus according to the invention, in which Fig. 10(a) shows the side elevation of the overall construction, and Fig. 10(b) is a partial enlarged view of Fig. 10(a);
Fig. 11 is an illustration showing an example of an inspection employing a plurality of electron beams by the electron beam generating means 2 of the invention;
Fig. 12 is an illustration showing an example of the construction of the electron beam generating means 2 and detecting means 4 in the construction for detecting the backscattered electron or secondary electron;
Fig. 13 is an illustration showing an example of a construction for oscillating or scanning the electron beam generating means 2 in the pattern inspection apparatus of the invention;
Fig. 14 is an explanatory illustration showing a scanning condition of an electron beam in Fig. 13;
Fig. 15 is an illustration showing an example of a drive means for the electron beam generating means 2 for performing simultaneous inspection for adjacent samples in the pattern inspection apparatus according to the invention;
Fig. 16 is an illustration showing an example of an inspection judgement circuit when the drive means for the electron beam generating means in Fig. 15 is employed;
Fig. 17 is a plan view showing an example when the pattern inspection is performed employing the drive means of the electron beam generating means of Fig. 15;
Fig. 18 is an illustration showing an example of a defective portion in the same to be detected through pattern inspection;
Fig. 19 is a block diagram showing a principal of the pattern inspection apparatus according to the invention;
Fig. 20 is a block diagram showing the first embodiment of the pattern inspection apparatus of the invention;
Figs. 21(a) to 21(e) show waveforms in various portions of the pattern inspection apparatus of Fig. 20;
Fig. 22 is a section showing a construction of an electron beam irradiating section in the embodiment of Fig. 20;
Fig. 23 is a similar view to Fig. 22 but showing the second embodiment of the pattern inspection apparatus according to the invention;
Fig. 24 is a similar view to Fig. 22 but showing the third embodiment of the pattern inspection apparatus according to the invention;
Fig. 25 shows a major part of the conventional pattern inspection apparatus;
Fig. 26 is an illustration showing an example of a drawback due to the fluctuation of a spot diameter in the prior art;
Fig. 27 is an illustration showing an example of a drawback due to the fluctuation of a deflection angle in the prior art;
Fig. 28 shows a principal of another embodiment of the pattern inspection apparatus according to the invention;
Fig. 29 shows a major part of another embodiment of the pattern inspection apparatus of Fig. 28;
Figs. 30(a) and 30(b) show details of the major part of a circuit C_l with a plan view including the circuit C_i;
Fig. 31 is an illustration of a connection when an electrode voltage Vdzi of a converging electrode Edzi is adjusted;
Fig. 32 is an illustration showing a layout of the basic pattern in one embodiment;
Fig. 33 is a conceptual illustration showing a manner for measuring a spot diameter of a spot in a knife edge method according to one embodiment;
Fig. 34 is a conceptual illustration showing a manner for measuring a spot diameter by a light metal and a heavy metal according to one embodiment;
Fig. 35 is an illustration showing one embodiment of the pattern inspection apparatus according to the invention;
Fig. 36 is an illustration showing one embodiment of the pattern inspection apparatus according to the invention;
Fig. 37 shows an arrangement of one embodiment of the detection means of the invention;
Fig. 38 shows an example of the arrangement of the detection device according to one embodiment of the invention;
Fig. 39 is an illustration showing one embodiment of the pattern inspection apparatus according to the invention;
Fig. 40 is an illustration showing the construction of a signal processing section in one embodiment of the pattern inspection apparatus of the invention;
Fig. 41 is illustration showing detection signals upon the presence and absence of a pattern;
Figs. 42(a) to 42(c) are illustrations showing one embodiment of the pattern inspection apparatus in which (a) shows a fragmentary illustration showing a concept of the embodiment, (b) is a

plan view of a mask formed with openings and (c) shows a graph for identifying a position of the mask with the openings.

Fig. 43(a) to 43(d) are illustrations showing wave forms used in a modulation method in another embodiment of the present invention;

Fig. 44 is an illustration showing a switching means used in the present invention;

Fig. 45 is an illustration showing another type of the switching means used in the present invention; and

Fig. 46 is an illustration showing a real time controlling circuit used in the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Preferred embodiment of a pattern inspection apparatus according to the present invention will be discussed herebelow in detail with reference to the accompanying drawings.

Fig. 1(a) is a brief illustration of one embodiment of the pattern inspection apparatus according to the present invention. Fig. 1(b) is a brief illustration of another embodiment of the pattern inspection apparatus according to the invention.

In both of the embodiments of Figs. 1(a) and 1(b), a pattern inspection device 1 comprises an electron beam generating means 2 having an electron gun for generating at least one electron beam that is accelerated and converged into a predetermined diameter for irradiating on an inspecting sample, a movable support means 3 for supporting the inspecting sample, a detecting means 4, in which a plurality of electron detecting elements for detecting the electron containing information associated with the construction of the inspecting sample are arranged in alignment, and a detection signal processing means 5 for processing information output from respective electron detecting elements of the detecting means 4 simultaneously or in parallel formation.

Fig. 1(a) is basically designed for an inspection of the circuit pattern by transmitting electron beam through the inspecting sample, such as the mask or so forth. On the other hand, the apparatus of Fig. 1(b) is basically adapted to use the secondary electron or the backscattered electron generated in the inspecting sample by irradiating the electron beam to the inspecting sample, such as the wafer, for performing an inspection.

At first, discussion will be provided for the electron beam generating means 2 to be employed in the preferred embodiment of the pattern inspection apparatus according to the present invention. As set forth above, the conventional method employing the light beam has a limit of resolution due to diffraction effect and therefore, is not suitable for pattern inspection of the mask, wafer or so forth with high circuit pattern density and high package density. In contrast to this, according to the present invention, the electron beam as a charged particle is basically employed. In addition, in the shown embodiment of the pattern inspection apparatus according to the present invention, the electron beam generating means 2 is designed to generate a highly converged electron beam.

Namely, one example of the electron beam generating means 2 comprises an electron gun 21, and an electron optical system 25 including an electromagnetic lens 22, a deflector 23 and an electromagnetic lens 24.

In the drawings, the movable support means 3 comprises a sample stage 31 for supporting the inspecting sample S, such as the mask or so forth, thereon, a XY stage drive mechanism 32 for shifting the sample stage 31 horizontally in one dimensional or two dimensional directions, and a laser interferometer 33, for example, for detecting a position of the sample stage 31 and generating control information signal.

On the other hand, in Fig. 2, the detecting means 4 composed of a plurality of electron detecting elements is provided beneath the movable support means 3. The detecting means 4 is designed to receive a plurality of electron beams and to process them simultaneously or in parallel formation. The output of the detecting means 4 includes a detection signal processing means 5 that comprises an amplifier 51 and a signal processing circuit 52.

In the conventional method for fabricating the circuit pattern T on the wafer or so forth, a single electron beam is employed so that the electron beam, which is finely focused by means of an appropriate electromagnetic optical system, is irradiated on the wafer or so forth and scanned along the intended pattern T so as to form an image of the pattern T.

In contrast to this, the present invention employs the electron beam for performing an inspection for checking whether the predetermined circuit pattern is correctly drawn or not, instead of drawing the circuit pattern. Therefore, in the electron optic system 25 of Fig. 2, the electron beam from the electron gun 21 is converged by a converging lens 22, such as the electromagnetic lens or so forth, into a predetermined beam size, and then irradiated onto the random position in a certain region of the mask by means of the deflector 23. Therefore, appropriately converged electron beam is irradiated on a given region of the circuit pattern as shown in Fig. 3a. Namely, according to the present invention, the beam diameter of the electron beam is adjusted by the electron optic system 25 so that the given region of the inspecting samples can be irradiated uniformly.

As shown in Fig. 3b, in the X-ray mask or the like, the substrate 26 is a thin film made of a material containing elements having a relatively small atomic weight, such as SiC. On such substrate 26, an ab-

sorber 27 made of a material containing an element having a relatively large atomic weight, such as gold or tantalum is patterned for absorbing X-ray. When the electron beam is irradiated to such mask S, the electron beam B irradiated on the absorber 27 is scattered by the heavy element thereof so as not to pass the mask or be significantly scattered. On the other hand, the substrate 26 is in the form of a thin film having thickness about 2 μm, and the scattering magnitude of the irradiated electron beam is substantially small. Therefore, the spreading width of the scattered electron beam is substantially small so that most of the electron passes through the substrate 26.

Accordingly, as shown in Fig. 3C and 4, only the transmission electron transmitted through the substrate 26 forms the expanded image on the detecting means 4 with an appropriate electron optic system 6. Since the transmission electron is detected, the dust, which will not significantly affect the X-ray and will be detected as a defect in the conventional method for detecting the secondary electron or the backscattered electron, will permit the electron beam to pass without absorbing a significant part of the electron beam so as not to cause a detection error occurring in the prior art.

As set forth above, according to the present invention, the electron beam B generated in the electron beam generating means 2 and shaped is irradiated onto the inspecting sample S, such as the mask or the like. Then, the transmission electron containing the two dimensional information of the inspecting sample is projected on the detecting means 4 through the electron optic system 6 to form the patten image T on the detecting means 4.

On the other hand, in the detecting means 4 as shown in Fig (5) to be employed in an embodiment of the pattern inspection apparatus as shown in Fig. 5 according to the invention, a plurality of electron detecting elements 41, such as semiconductor detecting elements formed by PN junction elements, are arranged in horizontal alignment in one or two dimensional directions. Each of the electron detecting elements receives the electron beam transmitting through the inspecting sample S and generates an electric signal corresponding to the intensity of the electron beam.

On the other hand, as the detecting means 4, a channel plane 41, such as that illustrated in Fig. 6, can also be employed.

In this case, the electron entering the channel is boosted to enhance S/N ratio. As set forth above, the mask pattern thus formed can be obtained as two dimensional image.

Each of the detection signal generated by the detecting means 4 is subject to processes, such as binarization, simultaneously or in parallel formation, by the signal processing portion 5 and transmitted to a memory section (not shown) or so forth and stored therein as a digital image signal. Subsequent process following the image processing is similar to those performed in the conventional mask inspection apparatus. Namely, by comparing the image informations of the same patterns of two chips to detect a difference therebetween to determine the presence of a defect. As an alternative, the defect can be detected by comparing obtained data with design data.

It should be noted that, in the movable support means 3 of the present invention, as shown in Fig. 7 in terms of one example, the inspecting sample S, such as mask or the like, is fixed to the sample stage 31. The sample stage 31 is rigidly fixed to an XY stage 32. For sample stage 31 and the XY stage 32, openings P are formed for passing the electron therethrough. The XY stage 32 is designed to be driven by means of an external driving motor 34 through a ball screw or so forth.

The foregoing discussion has been provided for the case in which the inspecting sample to be subject to the pattern inspection is the mask or the like, which-permits the electron beam to pass therethrough. However, the present invention can be equally implemented for the case in which the inspecting sample S is a wafer or the reticule having a substrate with a thickness of several mm and thus does not permit the electron beam to transmit therethrough by using the secondary electron.

In such a case, as shown in Fig. 1b, the detecting means 4 is disposed between the movable support means 3 supporting the inspecting sample S and the electron beam generating means 2. Other constructions should be understood as equivalent to those of the former embodiment of Fig. 1a.

In such a case, the electron detecting elements 41 of the detecting means 4 are of course directed toward the movable support means 3.

Furthermore, in the above-mentioned two examples of the present invention, the electron beam B generated by the electron beam generating means 2 may scan on the inspecting sample S appropriately by means of the deflection means. Such construction may be combined with the movable support means 3 so that the predetermined pattern T can be rapidly detected with high sensitivity for a small defect and high accuracy.

In order to satisfy the requirement for processing a large amount of data for efficiently inspecting the inspecting samples S, such as a mask, wafer or the like, having high circuit density and high package density, it becomes necessary to use a plurality of the electron beam generating means 2. The embodiment employing a plurality of electron beam generating means 2 is illustrated in Fig. 8. As can be seen, multi-construction of the electron beam generating means 2 employed in the embodiment in Fig. 8 has a construction such that the electron beam generating means 2 per se is divided into a plurality of sub-devices; each sub-device at least includes an electron emitter 101, a con-

verging electrode 102, and a deflection electrode 103 formed in the laminated construction.

The electron beam generating means 2 in Fig. 8 has a silicon substrate 100. In the silicon substrate, the electron emitter section 101 of silicon or hexagonal boron lanthanum is formed. On the same or separate silicon substrate, a plurality of layers of silicon oxide SiO_2 layer and a polycrystalline silicon layer are appropriately formed and the converging electrode 102 and the deflection electrode 103 are formed together with a hole for passing the electron with a fine processing technology. Then, the sub-assemblies thus formed are combined to obtain a multi-construction electron beam generating means 2.

The electron beams generated in the electron beam generating means 2 of the shown embodiment have an identical diameter to each other and are adapted to irradiate the predetermined area of a plurality of regions on the inspecting sample S uniformly.

In order to practically implement the pattern inspection apparatus according to the invention, it is, of course possible to use the electron beam generating means 2 of Fig. 2, which generates a single electron beam. However, in view of efficiency of inspection, it is preferred to employ a plurality of the electron beam generating means 2 as illustrated in Fig. 8.

When a plurality of the electron beam generating means 2 are employed, those electron beam generating means 2 can be arranged in one dimensional direction or in two dimensional directions.

It should be appreciated that the number of rows or columns and the arrangement pattern of a plurality of electron beam generating means 2 are not specified and can be determined in any number and any pattern depending upon intended application.

Particularly, as shown in Fig. 9a, on the circuit pattern T formed on the inspecting sample S, a plurality of electron beams B1, B2, B3, B4 ... Bn are irradiated simultaneously so that respective electron detecting elements 41 of the detecting means 4 may detect the transmitted electron or backscattered secondary electron. Therefore, by employing the multi-construction electron beam generating means 2, a fine and large amount of pattern information can be quickly and accurately obtained for enhancing efficiency of inspection.

On the other hand, when a plurality of the electron beam generating means 2 are employed, each electron beam generating means 2 may be designed to scan the electron beams B1, B2, ... over a predetermined region by the deflection electrode 103.

By employing such a construction to permit scanning of the electron beam, it becomes possible to enable quick inspection for any configuration of circuit pattern on the inspecting sample S by using scanning of the electron beam in combination with horizontal shifting of the movable support means 3.

In order to positively form a plurality of electron beams B, another construction of the electron beam generating means 2 as illustrated in Fig. 10 can be employed.

Namely, in the shown embodiment, a fine construction substrate 110 having the converging electrode 102 and the deflection electrode 103, excluding the electron emitter 101 as the electron gun, are fabricated. The fine construction substrate 110 is disposed between the electron beam generating means 2 composed of the electron gun 21 and the optical system 22 as shown in Fig. 10(a) and the movable support means 3. Then, the electron beam injected from the electron gun and having an uniform diameter formed by the optical system 22 passes a given number and given configurations of a plurality of electron beam passing holes 111 so that a plurality of the electron beams can be irradiated on the surface of the inspecting sample S.

In addition, by controlling deflection of the electron beams passing through the electron beam passing holes 111 respectively by means of the converging electrode 102 and the deflection electrode 103, a plurality of regions on the inspecting sample can be scanned simultaneously.

In the method set forth above, part of the circuit pattern on the inspecting sample S can be inspected at one time. As set forth above, by using the deflection means for scanning the electron beam in combination with the operation of the movable support means 3, the area to be inspected at one inspecting operation can be expanded.

Therefore, in the present invention, after inspection of the part of the region of the pattern T on the inspecting sample S is completed, the movable support means 3 is shifted by means of the XY stage 32 to shift the irradiating region of the electron beam.

As shown in Fig. 11, the detecting means 4 has a size corresponding to a small region. In each region, the electron detecting elements 41 of the detecting means 4 detect the presence and absence of the transmission electron in synchronism with scanning the electron beam to obtain pattern information at respective positions on the mask.

Fig. 12 shown the pattern inspection apparatus according to the present invention, which is designed for detecting the secondary electron or the backscattered electron from the mask or wafer on which the electron beam is irradiated. In the shown construction, the detecting means 4 having a plurality of electron detecting elements 41 is formed in the substrate 100, on which the electron beam generating means 2 is provided.

In the method of patten inspection according to the present invention, each of the electron detecting elements 41 is coupled with a corresponding the electron beam so as to detect the secondary electron or the backscattered electron from the irradiating position of the corresponding electron beam. Since the

electron beam and the electron detecting elements 41 are driven integrally, the secondary electron or the backscattered electron from the adjacent beam will be detected as mere noise. Therefore, degradation of a S/N ratio due to scattering of the adjacent electron beam will never occur. The detection signal from each detecting element 4 is transmitted to the signal processing section and subject parallel image processing, such as binarization. Then the resultant digital image signal is stored in the memory section. The image processing to be subsequently performed is similar to that in the conventional inspection apparatus.

In the present invention, it is possible to oscillate the electron beam generating means 2 per se within a predetermined region or to shift the electron beam generating means 2 in a two dimensional directions by a driving section 35, instead of employing the deflection means 103 in the electronic beam generating means set forth above, as shown in Fig. 13. With such a construction, as shown in Fig. 14, the electron beam B1, B2 can be irradiated in the predetermined region of the inspecting sample uniformly in a relatively wide range. Therefore, by driving the electron beam B to shift at high speed with a predetermined appropriate pattern by the driving section 35. This makes provision of the deflecting optical system 103 the electron beam generating means 2 unnecessary.

The electron beam generating means 2 is mounted on an oscillation stage that is driven to oscillation in a substantially small range at high speed by the driving section 35. When a piezoelectric oscillation actuator, such as a piezoelectric element or the like is employed for driving the oscillation stage, high speed oscillation in at a frequency of several 10 Khz in a range of several 100 um can be realized.

In the practical construction of the pattern-inspection apparatus according to the present invention, two of the above-mentioned pattern inspection mechanisms are provided for respective chips. Two pattern inspection mechanisms are at identical positions so that the same positions of the chips can be inspected. The positions of the pattern inspection mechanisms are variable depending upon the size of the chips to be inspected. Namely, as illustrated in Fig. 15, the electron generation means 2-1 and 2-2 are mounted on fine adjustment stages 28 and 29 respectively, which can be adjusted by a slide 27 for adjusting the distance between stages. On the other hand, on the stage supporting the inspecting samples, it is possible to apply the piezoelectric oscillation element. Furthermore, it may also be possible to cause shifting of the electron beam in the X direction by the above-mentioned mechanical scanning means and to scan the electron beam in the Y direction by an electrostatic deflection electrode 103 by means of an electrostatic deflection electrode (or vis versus).

In the present invention, as shown in Fig. 16, the inspecting samples S1 and S2 are mounted on the movable support means 3. Respective samples S1 and S2 are irradiated by the electron beams in unison so that respective corresponding electron detecting elements 41_1 and electron detecting elements 41_2 detect the the secondary or backscattered electron reflected from the irradiated position to output the detection information. The detection information is processed by the amplifier 51 and the image memory 53 and then compared in the detecting signal processing circuit 52.

Fig. 17 shows a plan view illustrating a practical method for performing a comparison of the detected patterns between the samples S1 and S2. When the chip pattern T1 of the inspecting sample S1 and the chip pattern T2 of the inspecting sample S2 are compared, the first electron beam generating means 2-1 and the second electron beam generating means 2-2, between which fine adjustment of the distance is effected, are scanned according to the predetermined scanning pattern by the driving section 35. If addition, if required, by providing fine oscillation, a predetermined deflection is provided for the electron beam B. As an alternative, employing the deflection means incorporated in the electron beam generating means, the predetermined deflection is provided for the electron beam B. By this, the pattern T in the predetermined region can be completely scanned and inspected.

With the practical embodiments set forth above, by irradiating at least one electron beam to the predetermined region on the inspecting sample, such as the mask or wafer or so forth, and by using the secondary electron or backscattered electron reflected from the sample or the transmitted electron transmitted through the sample, the defect in the circuit pattern on the inspecting sample can be detected with satisfactorily high sensitivity and resolution and at high speed. Accordingly, it becomes possible to provide the pattern inspection device that can be adapted to an increase of the fineness of the circuit pattern and to an increase in the package density.

In addition, when the inspection is performed for the inspecting sample, such as X-ray mask or so forth, by detecting the transmission electron, erroneous detection caused by dust can be successfully prevented to enhance the accuracy of the inspection.

Next, another embodiment of the pattern inspection apparatus according to the present invention will be discussed.

With the foregoing embodiment, the object of the present invention can be attained. However, on the other hand, in the case of the pattern inspection apparatus that employs a plurality of parallel scanning electron beams, the respective electron flow entering the corresponding electron flow detecting sections may interfered with the electrons from the adjacent irradiating region. This degrades the S/N ratio at the boundary region between the adjacent irradiating re-

gions.

Therefore, by solving the above-mentioned problem, the effect of the present invention can be improved. Therefore, the shown embodiment has been proposed for attaining a shortened inspection time, and as well, to provide enhanced S/N ratio at any electron irradiating regions.

As set forth above, when a single electron beam is irradiated on the predetermined region of the inspecting sample for detecting the backscattered electron or the secondary electron generated by the irradiation of the electron beam by the corresponding backscattered electron or secondary electron detecting section, the secondary electron generated in the adjacent inspecting region can be superimposed on the backscattered or secondary electron from the region to be inspected. In such a case, an error, such as when the presence of the pattern is detected even though a pattern is not presented in the inspecting region, can result.

For avoiding superimposition of the secondary electron from the adjacent inspection region, various proposal have been made. In the shown embodiment, a plurality of electron beams are modulated into a pulse so that the pulse period of respective electron beams irradiating respective adjacent inspection regions are differentiated from each other. Upon detection of the secondary electron at a respective inspection region, the pulse period of the electron beam is synchronized so that only the synchronized pulse is processed for inspection. As an alternative, by calculating the pulse width of the electron beam for detecting the occurrence of the electron beam having a specific pulse width, measurement of the secondary electron of the corresponding inspection region takes place in response to the occurrence of the specific pulse width of the electron beam.

In addition, in the shown embodiment, the electron beams consisting of pulses having different periods are subject to a time-division based multiplexing process so that the secondary electron of the region to be inspected is measured in synchronism with the specific pulse.

Also, in the shown embodiment, a plurality of electron beams are respectively modulated and composed to form a modulated electron beam. With this modulated electron beam, the secondary electron beam of the region to be inspected is measured in synchronism with the specific pulse width.

Namely, in the shown embodiment, the electron beam is processed to form a pulse or to be modulated so that a time difference is provided in the measuring timing of the secondary electron at respective inspection regions to prevent the influence of a secondary electron from adjacent inspection regions.

In the present invention, the modulating process includes a time sharing process and a detection method as well as an ordinary modulation process.

Fig. 19 shows an embodiment of the pattern inspection apparatus according to the present invention, showing a principle. In Fig. 19, the reference numeral 301 denotes an electron beam supply means; 302 denotes an electron beam modulating means; 303 denotes an electron beam scanning means; 304 denotes an electron flow detecting means; 305 denotes a signal; 1 denotes a processing means, and 310 denotes the inspecting sample. It should be noted that the shown embodiment is directed to an example employing two electron beams. Also, the electron beam scanning means 303 is shown as a mechanical scanning means for shifting the electron beam supply means 301.

In order to accomplish above-mentioned object, the pattern inspection apparatus according to the present invention comprises an electron beam supply means (30) for supplying electron beams respectively irradiated on a plurality of irradiating regions of an inspection sample (310), an electron beam modulating means (302) for modulating respective electron beams to moduled signals having mutually distinct signal patterns, an electron beam scanning means (303) for shifting the irradiating position of respective electron beams in order, an electron flow detecting means (304) for detecting the electron flow from the inspecting sample (310) generated by the electron beam and including information relating to the construction of a respective irradiating region, and a signal processing means (305) for extracting a signal representative of the construction of a respective irradiating region from the output signal of the electron flow detecting means (304).

Respective electron beams supplied through the electron supply means 301 is modulated to the mutually distinct patterns of moduled signals by the electron beam modulating means 302. The moduled signals of the electron beams are scanned on respective irradiating regions on the inspecting sample via the electron beam scanning means 303. The electron flow generated at respective irradiating regions by irradiation of the electron beams are gathered by incidence to the common electron current detecting means (304) and subsequently input to the signal processing means 305. The signal processing means 305 thus derives signals indicative of the construction of respective irradiating regions.

Further detailed discussion about the foregoing embodiment will be given hereafter with reference to the drawings. Fig. 20 shows, in the form of a diagram, the construction of the shown embodiment of the pattern inspection apparatus. In the drawings, an electron generating element 411 forming a part of the electron beam supply means includes a plurality of electron emitters 411 and 412 on the common plane. The electron emitters 411 and 412 emit electron beams 361 and 362. The electron beams 361 and 362 are modulated by modulating electrodes 321 and 322

that form the electron beam modulating means and receive an modulating signal from the signal processing section 305.

The electron beams 361 and 362 passes a common converging electrode 312 that converges respective electron beams in a respective fine area, and deflection electrodes 331 and 332 provided for respective electron beams 361 and 362 to reach the inspecting sample 310. The converging electrode 312 forms a part of the electron beam supply means. The deflection electrodes 331 and 332 scan respective irradiating regions 401 and 402 of the inspecting sample by shifting the electron beams 361 and 362 in order within the irradiating regions 401 and 402.

The inspecting sample 310 is fixed on the sample stage 309. The sample stage 309 is adapted to be shifting in X, Y and Z directions via a XYZ stages. The XYZ stages are designed to be driven by respectively corresponding drive motors through ball screws or so forth. When scanning the electron beam on respective irradiating regions 401 and 402 the deflection electrodes 331 and 332 are completed, the x-y stage motor is driven for scanning another irradiating region of the inspection sample 310.

On the upper portion of the inspecting sample 310, the common electron flow detecting section 304 is provided to commonly detect the backscattered electron 371 and 372 generated by irradiation of the electron beams 361 and 362 on respective irradiating regions 401 and 402. The output of the electron current detecting section 304 is input to the signal processing section 305.

The signal processing section 305 comprises a CPU 351 for controlling the overall pattern inspection apparatus, modulated signal generating section 352 and 353 for providing the modulating signals for respective modulating electrodes 321 and 322 via amplifiers 357 and 358, a signal discrimination section 354 for discriminating the configuration signals from the irradiating regions 401 and 402 taking respective modulated signals from the modulating signal generating sections 352 and 353 as reference signals, an image processing section 355 for receiving the output of the signal discriminating section 354 to convert the information contained therein into a binary image signal, and a memory section 356 for storing the binary image signal.

Fig. 21 shows waveforms of the signals to be used for discussion about respective signals in a pattern inspection apparatus. In this embodiment, the modulating means forms pulses of the sequence of the electron beam for alternatively using two pulses having mutually different pulse phases. In the present invention, the modulated method includes a method for making a pulse signal from a continuous beam. The modulated pulse signals illustrated in Figs. 21(a) and 21(b) are pulse signals having mutually similar pulse frequencies and peaks thereof appear in alternative fashion. Namely, the shown embodiment is directed to the example of signal processing in time-division multiplexing.

The signal of the electron flow gathered in the electron detecting section 4 by inciding thereto from respective irradiating regions is illustrated in Fig. 21(c) as the input for the signal discriminating section. Namely, when the modulated pulse signal 1 is H level, the input signal for the signal discriminating section discriminates the signal as the configuration signal of the irradiating region 401. On the other hand, when the modulated pulse signal 2 is at H level, the signal discriminating section discriminates the input as the configuration signal of the irradiating region 402.

In the signal discriminating section 354, by employing the pulse signal 1 as the reference signal, the output as illustrated in Fig. 21(d) may be obtained as the configuration signal of the irradiating region 401. On the other hand, by employing the pulse signal 2 as the reference signal for discrimination, the output 2 illustrated in Fig. 21(e) is obtained as the configuration signal of the irradiating region 402. The amplitude of these outputs represents the pattern at respective irradiating regions 401 and 402. These signals are thus discriminated by the signal discriminating section 354 and converted into the digital signals by the image processing section 355 parallel to each other.

The output of the image processing section 355 is stored in the memory section 356 as digital image information. By a signal processing section 305, which is not shown and following the memory section 356, the conventional signal processing is performed for implementing a pattern inspection.

An example is given to the signal frequency to be used. When a period, in which each electron beam is processed and modulated into a pulse signal, and namely, the period in which the electron stays on the pulse generating electrode, is 500 nsec, approximately 2 Mhz is used as the frequency of the pulse signal. In such a case, assuming the total number of irradiating regions to be irradiated in parallel formation according to the present invention is 100, and by employing time sharing multiplexing, the pulse width of a respective modulated pulse signal becomes 500 nsec./100 = 5 nsec. Accordingly, in such time sharing multiplexing, as pattern information of the inspecting samples, it becomes possible to perform an inspection for 2M x 100 every second. Namely, 200 pixel/seconds is possible.

On the other hand, instead of using the time sharing multiplexing, it is possible to use pulse signals having the same frequency and mutually different pulse width, and even in this case, the signal discrimination taking the moduled signals as reference signals is similar to the former embodiment.

Fig. 22 shows a section of the detailed construction of the electron beam irradiating portion in the embodiment of Fig. 20. In Fig. 22, shows an electron

beam generating section 311 forming the electron beam supply means, the converging electrodes 421 to 423 forming three stage lens, and modulating electrodes 321 and 322 disposed therebetween. On the side of a traveling direction of the electron beam of the converging electrodes 421 to 423, the deflection electrodes 331 and 332 are provided.

In the construction of the electron beam irradiating portion, the electron beam generating section 311, the modulating electrodes 321 and 322, the converging electrodes 421 to 423 and the deflection electrodes 331 and 332 are preferably formed on the silicon substrate employing fine processing technology. Such construction has been reported in G. W. Jones et al. "Microstructure for Particle beam Control", J. Vac. Sci. Technol. page 2023 to 2027, B6(6), Nov/Dec 1988, for example.

As shown in Fig. 22, the converging electrode is formed by three stage electrostatic lens 421, 422 and 423 arranged in order of traveling direction of the electron beams 361 and 362. The front stage electrostatic lens 421 is set at high potential with respect to the electron beam generating section 311 and commonly used as an output line for extracting an electron from the electron emitters 411 and 412.

The rear stage electrostatic lens 423 is maintained at equal potential to the front stage electrode 421. The intermediate electrode 422 is maintained at a different potential to the electrodes 421 and 423. The three stage electrostatic lens converge the electrons emitted from the electron emitter 411 and 412 and having a tendency to be scattered the same into the electron beam for irradiating a substantially small area.

The modulating electrodes 321 and 322 modulates electron beams 361 and 362 into pulses according to the modulating signals. In such a case, peaks of the modulating signal become equal potential to the electron beam generating section 311 to permit the electron beam, and the bottom of the pulse of the modulating signal becomes negative to shut the front stage electrostatic lens 421 from the electron beam generating section 311 to block a emission of the electron to control the generated electron amount from the electron beam generating section 311.

The deflection electrodes 331 and 332 are provided the same scanning signals so that scanning voltages are applied between the deflection electrodes respectively in opposing X and Y directions. By deflecting the electron beams simultaneously in the same direction according to the scanning voltage, scanning of respective irradiating regions occurs simultaneously.

The manner of scanning is illustrated in Fig. 14. The electron beams 361 and 362 converging at the irradiating regions 401 and 402 by the effect of the converging electrodes are shifted in four directions parallel to the irradiating surfaces of respective irradiating regions 401 and 402 of the inspecting sample by respectively corresponding deflection electrodes, as illustrated by arrows so that all regions in the irradiating regions 401 and 402 can be scanned.

Fig. 23 is a section showing another construction of the electron beam irradiating portion in the pattern inspection apparatus according to the present invention that corresponds to that illustrated in Fig. 10. In Fig. 23, the electron beam generating section 317 is differentiated from that shown in Fig. 22 and has an electron supplying means 317 for supplying uniform electrons, and a shielding plate 318 having fine apertures 481 and 482 at positions corresponding to respective irradiating regions for introducing electron beams therethrough. An accelerating voltage is charged at the position between the shielding plate 318 and the front stage electrostatic lens 421 for accelerating the electron. The other construction is the same as that of Fig. 22.

Fig. 24 is a section showing the electron beam irradiating portion in the third embodiment of the pattern inspection apparatus according to the present invention. In the shown embodiment, in place of the modulating electrodes 321 and 322 for modulating the electron beam as illustrated in Fig. 22, a deflection modulating electrodes 323 and 324 for deflecting the electron beams 361 and 362 in a direction perpendicular to the traveling direction as illustrated by broken line A, and a passing control section 325 and 326 for blocking the deflected electron beam by blocking walls 451 and 461 are provided. The other construction is the same as that of Fig. 22. The signal waveform in this embodiment is similar to that shown in Fig. 21 and therefore discussion thereof is omitted.

In the shown embodiment, by sequentially deflecting the axis of the electron beam transversely, a pulse form electron beam is irradiated on the irradiating region.

Fig. 43 shows signal wave forms used in another embodiment of the modulating method of the present invention in which each one of main pulse wave signals is modulated by adding thereto a plurality of another pulsed signals each having a frequency different from each other and the main pulse wave signal per se can be discriminated from the detected signal, a plurality of the pulse wave signals each having a frequency different from each other are integrated in the main pulse wave signal by tuning the main pulse wave signal with the same frequency as the main pulse wave signal originally possesses.

For example, Fig. 43 (a)-1 shows a wave form of the main pulse wave signal in a beam used in the present invention while Fig. 43 (a)-2 shows a wave form of the noise caused by an interference signal generated by adjacent pulse wave signal beams.

The former pulse wave signal has a frequency different from that of the latter and Fig. 43 (a)-3 shows a wave form of a modulated pulsed wave form in which the main pulse wave signal 1 is modulated by

the noise pulse wave signal 2 and thus a detector detects the pulse wave form 3 in that the noise is incorporated thereinto.

Note, that in Fig. 43 (a)-3, a dotted line represents an true pulse wave form of the main pulse wave signal 1.

Fig. 43 (b) shows a pulse wave form of a modulated pulsed wave form in which the main pulse wave signal 1 is interfered by a plurality of noise pulse wave signals---, each having a different frequency from each other.

Note, that in this embodiment, the pulse wave signal as shown in Fig. 43 (b) is formed by modulating the main pulse wave signal 1 by a plurality of noise pulse wave signals.

Fig. 43 (c) shows a modulated wave form obtained from the pulse wave form as shown in Fig. 43 (b) by passing it through a band-pass filter having the same frequency as the main pulse wave signal originally possesses as a center of the band used and a continuous line 5 represents the wave form of the modulated wave form of the pulse wave signal 1 in which both of the high frequency components and low frequency components are deleted from the final wave form.

Note, that the wave form as shown in Fig. 43 (c) for example, represents a signal level showing that the pulse wave signal 1 detects white patterns, i.e., the fact that patterns are existing.

On the other hand, Fig. 43 (d) shows a modulated wave form obtained from another pulse wave form generated in a condition in which no pattern exists by the same way as explained above, and a continuous line 6 represents a signal level showing that the pulse wave signal detects black patterns, i.e., the fact that no pattern is existing.

Accordingly, the fact that whether or not the pattern exist on the substrate, can be discriminated by detecting the difference of amplitudes of the two separate wave forms thereof.

With the shown construction, a plurality of irradiating regions can be scanned by the electron beams simultaneously enabling high speed inspection. Also, interference of the adjacent electron beams can be successfully prevented to obtain the configuration signals with an enhanced S/N ratio. Therefore, the shown embodiment of the pattern inspection apparatus can perform accurate inspection in a short inspection period.

Although the foregoing embodiment attains a remarkable gain in the improvement of the efficiency of inspection and avoids mutual interference of adjacent electron beams, there is the following unsolved problem.

Namely, the foregoing pattern inspection apparatus according to the present invention, is composed of a plurality of electron guns, beam extracting electrodes, converging electrodes, deflection electrodes. When respective electron guns or respective electrodes have a tolerance in production, a slight variation is induced in the characteristics of the electron beams so as to cause a fluctuation of the focus points of the electron beams. In some cases, the focus point is set in front of or behind the irradiating surface to cause focus error at the image to be inspected. This problem is encountered not only in pattern inspection but also in the drawing of a pattern employing the electron beam exposure device. To solve this problem, the electron beams emitted from a plurality of electron guns have to be uniformly irradiated on the inspecting surface. The following embodiment of the pattern inspection apparatus proposes a solution for this problem by comparing each electrode with a preliminarily provided reference electrode to individually adjust the characteristics thereof and make it consistent with that of the reference electrode.

The following is a discussion for the embodiment of the pattern inspection apparatus according to the present invention.

Fig. 25 shows the construction of the major portion of the embodiment of the pattern inspection apparatus according to the invention. In Fig. 25, the reference numeral 501 denotes the electron beam generating means. The electron beam generating means 501 has a silicon substrate 502, on which a plurality of (two are shown in the drawing) electron emitters 503 and 504 are formed of silicon, metal, such as Ta or the like, or lanthanum boride or the like. Below the electron emitters 503 and 504, an extraction electrode 505, a converging electrode 506, a deflection electrode 507 and detectors 508 and 509 are laminated in order. The reference numeral 510 denotes an anode; 511 and 512 denotes grounding electrodes; 513 denotes an inspecting sample, such as an exposure mask or the like, on which a fine pattern (omitted from illustration) is formed.

From the electron emitters 503 and 504, charged particle beams (electron beams) 503a and 504a are emitted 504a having a beam current corresponding to the electrode voltage V_5 of the extraction electrode 505. The electron beams 503a and 504a is then converged with a convergence ratio corresponding to the electrode voltage V_6 of the converging electrode 506. Subsequently, the electron beam 503a and 504a are deflected at an deflection angle corresponding to the electrode voltage V_7 of the deflection electrode 507 and thus irradiated onto the sample 513 in the form of a spot.

Then, the backscattered electron or the secondary electron (illustrated by broken line) is discharged from the surface of the sample in response to the irradiation of the electron beams 503a and 504a. These emitted electrons are caught by the detectors 508 and 509 and converted into electric signals, for example, an X-ray mask, and a greater amount of emitted electrons are emitted from the electron beam absorber

than from the mask membrane forming the sample 513, because the material (gold, tantalum and other elements having a large atomic weight) used for the electron beam absorber has a higher generation ratio of backscattered electrons or the secondary electrons than the material (silicon or other elements having a small atomic weight) used for the mask substrate.

Accordingly, by simultaneously irradiating a plurality of electron beams 503a and 504a for unitarily processing the outputs of the detectors 508 and 509 for respective electron beams, a fine and large amount of pattern data of the pattern formed on the surface of the sample 513 can be inspected rapidly and accurately. Also, when the apparatus is applied to a pattern drawing apparatus, a circuit pattern having a fine and large capacity for pattern data can be rapidly and accurately drawn.

However, in the above-mentioned electron beam apparatus, since common electrodes are provided for a plurality of electron beams, it can happen that spot diameters of the electron beams can be slightly differentiated, the beam axes can be slightly offset, or the deflection angles do not become precisely coincident with each other, because of mechanical tolerance of the electromatnetic optical systems for respective electron beams. Therefore, in view of an improvement of making the electron beam characteristics coincident with each other with high precision, there still remains a technical problem to be solved.

Fig. 26 illustrates an abstract of a problem arising due to a fluctuation of the spot diameter of the electron beam. Though a defect in the circuit pattern that can be detected with smaller spot, it is often difficult to detect the same with a larger spot. The illustrated waveforms a and b represent the detected intensity of the backscattered electron or secondary electron reflected from the sample surface or the transmission electron passing through the sample. Although it is not illustrated, by providing the detector at the back side of the sample, the transmission electron can be caught and converted into an electron signal to obtain one dimensional information of the transmission path in addition to two dimensional information of the sample. In the case of a large spot, the signal intensity at the defective portion becomes small to make it difficult to recognize the defect.

Fig. 27 is an explanatory illustration showing a problem arising due to a fluctuation of the deflection angle. When the deflection angle becomes excessive, the electron beam can enter the adjacent irradiating region to create an overlapping region to form a multiple detection region. On the other hand, when the deflection angle is too small, a non-irradiating region can be left between adjacent irradiating regions creating a non-inspected region.

Such a problem will occur even when the electron beam system is applied to a pattern drawing apparatus. Namely, the fluctuation of the spot diameter may degrade the precision of patterning. On the other hand, the fluctuation of the deflection angle may cause degradation of the precision of pattern drawing positions.

Therefore, the present invention proposes an electron beam system that enables the adjustment of characteristics of a respective individual electron beam and thus to make the characteristics of the overall electron beams uniform with precision.

Fig. 28 shows one embodiment of the electron beam system implementing the invention set forth above. As shown in Fig. 28, on a common substrate 520 or separated substrate arranged on the same plane, a plurality of electron emitters 521 are formed. For each of the individual electron emitters 521, an extraction electrode 523 for extracting a charged particle beam 522 from the electron emitter, a converging electrode or a converging coil 524 for providing a converging ratio corresponding to the electrode voltage or an energization current, a deflection electrode or deflection coil for providing a deflection angle corresponding to the electrode voltage or an energization current to the charged particle beam, a detector 529 for detecting the secondary electron or the backscattered electron 527 reflected from the surface of the sample 526 or an transmission electron 528 passing through the sample 526, and an adjusting means for all or part of the electrode voltage or energization current provided for the extraction electrode 523, the converging electrode or converging coil 524 and the deflection electrode or deflection coil 525, are provided.

In the shown embodiment, the electrode voltage or the energization current for each of the charged electron beams can be adjusted independently. For example, by adjusting the electrode voltage of the converging electrode 524, the spot diameter of the charged particle beam can be adjusted. On the other hand, by adjusting the electrode voltage of the extraction electrode 523, the beam current is varied to adjust the spot diameter. As an alternative, by adjusting the electrode voltage of the deflection electrode 525, the charged particle beam axis can be adjusted.

Therefore, the overall electron beam characteristics can be unified with high accuracy.

The practical embodiment of the electron beam system according to the invention will be discussed herebelow.

Figs. 29 to 35 shows the practical embodiment of the electron beam system that is directed to application of the pattern inspection apparatus.

In Fig. 29, the reference numeral 530 denotes one or more substrates of multi-layer structure. For the substrate 530, a plurality of (three are shown in the drawing) of electron emitters 531 to 533 formed of a metal, such as or silicon, Ta or the like or lanthanum boride or the like are formed. It should be appreciated, that the substrate 530 can be a common substrate for

the electron emitters 531 to 533, or as an alternative can be an individual independent substrate for each of the electron emitters 531 to 533. In the further alternative, the substrate 530 can be formed by laminating and holding a plurality of substrates. However, in the case of the individual independent substrate, the individual substrates have to be arranged on a common plane and integrated by being fixed to each other.

Below, respective electron emitters 531 to 533, an extracting electrodes Ea_i (i is 531, 532 and 533, same in the following), an anode Eb_i, a first grounding electrode Ec_i, a converging electrode Ed_i, a second grounding electrode Ee_i, a deflection electrode Ef_i and a detector S_i are provided in order. These elements are provided exclusively for corresponding to one of the electron emitters 531 to 533.

Here, discussion will be provided for major electrodes. The extraction electrode Ea_i is adapted to extract a charged particle beam (electron beam) B_i having a beam current corresponding to given electrode voltage Va_i from the electron emitter 531 (or 532 or 533). The converging electrode Ed_i converges the electron beam by generating an electric field having an intensity corresponding to the charged electrode voltage Vd_i. The deflection electrode generates an electric field corresponding to the charged electrode voltage Vf_i for providing a deflection angle for the electron beam. Other electrodes (anode electrode Eb_i, the first grounding electrode Ec_i and the second grounding electrode Ee_i) are adapted to assist in the function of the extraction electrode Ea_i, or form an electric filed distribution for converging electrons between the converging electrode. For these electrodes, the same potential of electrode voltage Vg (grounding potential) is provided.

The above-mentioned construction merely shows the typical construction in number of electrodes, layout of the electrodes and distribution of the charged voltages, and should not be regarded as essential for implementing the invention. Furthermore, although, the discussion is provided for the example employing electrostatic convergence and electrostatic deflection, the drive type should not be specified as the electrostatic type but can be electromagnetic convergence and electromagnetic deflection. Also, it is possible to use an electrostatic driving type and an electromagnetic driving type in combination. However, in the case that the electromagnetic type driving is employed, the converging electrode and the deflection electrode should be replaced with the converging coil and the deflection coil. Also, the driving power to be applied to these elements is an engergization current.

The detector S_i provided for respective electron beam B_i is adapted to catch the backscattered electron or the secondary electron emitted from the surface of the sample 534, such as the X-ray exposure mask or the like, to mark for aligning the sample 534 to be exposed or a correction unit pattern, which will be discussed later, and to convert into an electric signal. The electric signal output from respective detectors S_i contains information representative of the configuration of a fine portion of the electron beam absorber (not shown) on the sample 534, i.e., the circuit pattern in a fine portion. Accordingly, the two dimensional information of the sample 534 can be reproduced from all of the electric signals. Therefore, the defective portion (white defect or black defect, for example) in the fine pattern can be accurately identified. Alternatively, although it is not illustrated, by providing the detector at the back side of the sample, the transmission electron can be caught and converted into an electron signal to obtain one dimensional information of the transmission path in addition to two dimensional information of the sample.

Here, the circuit C_i for a respective beam formed by fine processing technology on the upper surface of the substrate has a function as the adjusting means, as set forth above, and adapted to generate necessary voltages Va_i, Vd_i, Vf_i and Vg) by voltage divider resistors, for example.

Fig. 30 shows the plan view of the circuit C_i and the detail thereof. The power source voltage V_o introduced into the circuit C_i is taken out as Va_i, Vd_i or Vf_i through a parallel resistor network including several resistors (R_1, R_2, R_3 and R_4). By selectively cutting off the resistor elements, the voltage can be adjusted. As a method of voltage adjustment by a parallel resistor network is specific to the shown parallel resistor network but can be a series resistor network or combination thereof. Also, instead of cutting off the selected resistor, an equivalent voltage adjustment can be done by adding a selected resistor(s). Furthermore, respective elements in the resistor network can be formed by transistors. As a suitable device for cutting off and connecting the fine pattern, a mask repair device disclosed in "Precision Mechanics Paper" (Vol. 53, No. 6, pages 15 to 18) June 5, 1987, Precision Mechanics Association), for example, in which high luminous FIB (Focused Ion Beam), higher than or equal to $1A/cm^2$ having a beam diameter less than or equal to 0.1 μm, is generated for correction (cutting out of black defect or connection by deposition of the material vapor) of the pattern defect (black or white defect) on the photo mask by the FIB.

Referring to Fig. 31, by selectively cutting off respective resistor elements R_1 to R_4 of the circuit C_i, the electrode voltage Vd_i for converging the electron beam B_i can be appropriately adjusted by applying it to the converging electrode Ed_i and varying the voltage division ratio of the power source voltage V_0. By this, the converging ratio of the electron beam B_i converged by the converging electrode Ed_i can be adjusted to adjust the spot diameter.

On the other hand, although it is not illustrated in the drawing, by adjusting the electrode voltage Va_i to

be applied to the extraction electrode Ea_i, the amount of the beam current of the electron beam B_i can be adjusted independently since there is a correlation between the beam current and the spot diameter.

Furthermore, though it is not illustrated, by adjusting the electrode voltage Vf_i to be supplied to the deflection electrode Ef_i the beam axis and the deflection angle of the electron beam B_i can be adjusted.

Fig. 31 is an illustration of a connection when an electrode voltage Vdzi of a converging electrode Edzi is adjusted.

As set forth above, since the characteristics of each of the electron beams can be adjusted independently of each other, the characteristics of the overall electron beam can be unified. Therefore the shown embodiment is successful in solving the problem concerning the inconsistency of beam axes or deflection angles.

Next, a preferred example for detecting the fluctuation of the characteristics of the electron beam B_i will be discussed. Fig. 32(a) shows a plan view of a table 535 that is movable in X-Y directions when mounting the sample 534. At the predetermined position of the table 535, a reference pattern section 536 is fixedly provided so that it can be placed within the irradiating region of a plurality of electron beams by shifting the table 535. Fig. 32(b) shows a side elevation wherein the reference pattern portion 536 is positioned within the irradiating region 537 of the electron beams. A plurality of electron beams discharged from an electron beam generating means 538, including a plurality of electron emitters, are irradiated on the reference pattern portion 536.

In the reference pattern portion 536, unit patterns (element having a large atomic weight is used) in the number corresponding to the number of the electron beams and precisely designed are arranged in regular arrangement. The backscattered electron or secondary electron is discharged from respective unit patterns and circumferential non-patterned portions, or the transmission electron passing through respective unit patterns and the circumferential non-patterned portions are detected by the detector S_i.

Fig. 33 shows when the electron beam is irradiated on the single unit pattern and the circumferential non-patterned portions. It is assumed that the relative positional relationship between the electron beam and the unit pattern is shifted from the position A to a position B and then from the position B to a position C by deflecting scan or fine shifting of the table 535. At the position A, all of the electron beam is irradiated on the non-patterned circumferential portion. Therefore, the largest amount of the transmission electron passes through the non-patterned portion. At the position B, the electron beam irradiates approximately half of the unit pattern. At this time, the amount of transmission electrons becomes lesser than that the position A. On the other hand, at the position C, the electron beam fully irradiates the unit pattern. Therefore, no transmission electrons is obtained. Fig. 33(b) is a graph illustrating a variation of the beam current representative of the variation of the transmission electron while shifting from the position A to the position C. As can be seen, the line La shows a variation of the beam current, in that the beam current is initially large and abruptly decreases across the position B and then becomes 0. Fig. 33(c) shows a graph Lb illustrated a differentiated value of the line La. As can be seen, the differentiated value becomes 0 at both ends and becomes maximum at the position B. With a width of the differentiated value curve, Lb (generally half value width) represented the width of the electron beam and the spot diameter. Such a measurement is called a knife edge method.

Fig. 34 illustrates another manner. In Fig. 34(a), for the reference pattern formed by a combination of the light element, having a relatively light atomic weight a heavy element, such as tantalum, the electron beam is irradiated in the same manner. Then, because of the difference of atomic weight, the difference is induced in the generation of the backscattered electron or the secondary electron so that the current variation curve Lc as shown in Fig. 34(b) is obtained while shifting from the position A to the position C. Similarly to the knife edge method, the curve swiftly varies across the position B. Then, with the differentiated values, a differentiation curve similar to Fig. 33(c) can be obtained for measuring the spot diameter.

The foregoing examples of a practical measurement of the spot diameter is adapted for a single electron beam. In the modification, the spot diameters of a plurality of electron beams can be measured through the process as illustrated in Fig. 35.

Fig. 35(a) illustrates a preferred plane configuration of the unit pattern. Here, by utilizing the triangular unit pattern, the electron beams are scanned in the three directions F_1 to F_3 respectively perpendicular to the three edges of the triangle. By this method, the pure circular spot diameter of the electron beam can be accurately measured. This method also permits a measurement of longer and shorter axes of an elliptic spot causing astigmatism.

Now, it is assumed that for respective unit patterns P_1 to P_5 forming the random unit pattern, the electron beams B_1 to B_5 respectively having different spot diameters are irradiated. The scanning direction is set to F_1. The differentiation curves of beam currents of respective unit patterns are shown in Fig. 35(c). L_1 shows the differentiation curve corresponding to the electron beam B_1. L_2 shows the differentiation curve corresponding to the electron beam B_2. Similarly, with respect to the electron beams B_3 to B_5, the differentiation curves L_3 to L_5 are obtained.

Comparing these curves L_1 to L_5, the curve L_5 corresponding to the electron beam B_5 having the small-

est diameter has a minimum width and the highest peak. Conversely, for the L_4 corresponding to the electron beam B_4 having the largest spot diameter, the width attains maximum value and the peak attains the lowest value. The differences between the curve L_5 corresponding to the minimum diameter and other curves L_1 - L_4 correspond to the differences of the spot diameters. Accordingly, by utilizing such a difference in the curves, the correction values for the spot diameters for respective electron beams can be derived.

On the other hand, as can be seen from Fig. 35(b), the beam axis (spot center) of the electron beam B_4 is slightly offset from the center of the oblique edge. Accordingly, by using such an offset amount of peak position, the correction value for the offset of the beam axes for a respective electron beam can be derived.

As the unit pattern, it is possible to use the stencil type pattern with openings. In such a case, it is desirable to provide current measuring devices, such as Farady cups beneath the openings.

Furthermore, as the above-mentioned circuit C_i, it is also preferable to use a variable power source device, such as a voltage regulator circuit, a programmable power source or so forth. In the former case, the correction value for the spot diameter or the beam axis offset is provided for the reference voltage, and in the latter case, the correction value is provided for the program input.

Furthermore, in the case that the subject of correction is an electromagnetic type, the above-mentioned circuit C_i becomes the current source. In such a case, using a resistance division, the current from the current source is appropriately divided. Namely, in the shown embodiment, the diameter and configuration of a respective beam can be independently measured so that the voltage or current to be applied to the electrode can be adjusted based on the result thereof, thereby making it possible to adjust the beam diameters of the electron beams substantially equal to each other.

In the above embodiment, a resistor network is used for precisely controlling the supplied voltage to the converging electrode but in the present invention, another switching means comprising a plurality of transistors also can be used as an alternative device instead of the resistor network.

Fig. 44 shows a switching means comprising a plurality of transistors TR1, TR2, TR3 and TR4, which can be used as a device for precisely controlling the supplied voltage to the converging electrode Edi.

Although in the previous embodiment, the control thereof can be carried out by cutting or connecting the resistor or resistors in the resistor network, in this embodiment, the control thereof can be carried out by controlling each one of these transistors in ON/OFF condition, respectively.

A digital-analog converter can be used as a typical type of this switching means and one of the representative circuit construction thereof is shown in Fig. 45 which is called as weighing constant current typed digital-analog converter.

In this circuit, the input terminals thereof comprise four bits B1 to B4 and thus the controlling operation can be carried out by applying any one of the control signals 1 or 0, respectively and accordingly the output thereof will be as follows;

$$VO = RI(B1/2 + B2/2^2 + B3/2^3 + B4/2^4)$$

Since there is an upper limit in the bit number in a DAC in practical use, the range of correction can be limited when the resolution is set excessively high. Therefore, it is desirable to use the adjustment by means of a DAC in combination with an adjustment by resistor. By this, a fine adjustment capability while maintaining a large adjustment range can be realized.

Further, in the present invention as explained in above embodiment, the adjusting the beam configuration can be carried out in real-time base and thus Fig. 46 shows one example of a controlling circuit for adjusting the beam configuration in real-time base.

The circuit comprises a signal discriminating portion 46-1 which corresponds to the signal discrimination portion 354 as shown in Fig. 20, a alanalog-digital convertors 46-2 and diginal-analog converters 46-5, a memory means 46-3, a processing means 46-4, and a plurality of lens electrodes 46-7.

In this circuit, when the signals output from each one of the detectors is discriminated by the signal discriminating portion 354 and then each one of the signal wave forms as shown in Fig. 35 is digitized by the analog-digital convertor 46-2 and stored in the memory means 46-3.

After that the processing means 46-4 processes the stored data to output a controlling data for adjusting the voltage of the conversion lens and it is output to the digital-analog convertor 46-7 provided on a substrate from which an analog controlling data is output to the lens electrode.

In the present invention, the variation of the deflection can also adjusted utilizing the above circuit.

As can be appreciated, according to the shown embodiment, since the characteristics of a plurality of electron beams can be independently adjusted, the characteristics of the overall electron beams can be precisely unified to avoid a fluctuation of the spot diameters, an offset of the beam axes of a fluctuation of the deflection angles.

In addition, the shown embodiment can effectively avoid interference of the backscattered electron between adjacent irradiating regions. Or, as an alternative, the degradation of the S/N ratio due to interference of the reflected beams from the adjacent region can be successfully compensated for with the following embodiment.

Namely, in order to improve the S/N ratio, the fourth aspect according to the invention is constructed

as shown in Fig. 42. The shown embodiment of the pattern inspection apparatus according to the present invention includes a plurality of electron emitters arranged in a matrix fashion, each of which has a fine electrode with sharply headed tip end, a gate surrounding the tip end of the fine electrode, a converging electrode, a deflection electrode and a detector provided for each of the electron emitters, in which electron beams are simultaneously irradiated on the surface of the sample from the electron emitters parallel to each other; the backscattered electron or the secondary electron from the surface of the sample is caught by a detecting surface of each detector. Based on the amount of the backscattered electrons or secondary electrons, the condition of the surface of the sample is inspected. A mask having an opening with a predetermined internal diameter is arranged so that the center of the opening is aligned with the axis of the electron beam, at a position between the surface of the sample and the detecting surface of the detector and is determined based on the distance from the surface of the sample to the detecting surface and the size of the detecting surface.

The practical construction of the shown embodiment will be discussed with reference to Fig. 35.

In Fig. 42(a), the reference numeral 610 denotes an electron beam injected from one of a plurality of electron emitters; 611 denotes an electron beam emitted from the adjacent electron emitter. The two electron beams 610 and 611 as typically illustrated are irradiated to two points P_1 and P_2 mutually distanced by a distance L, simultaneously. Then, the electron (or secondary electron) are emitted from the points P_1 or P_2.

The reference numerals 613 and 614 denotes detectors provided in the vicinity of the outlets of the electron beams 610 and 611. These detectors 613 and 614 catch the backscattered electrons or the secondary electrons of corresponding electron beam on the surface having the given area to output the electric signal proportional to the amount of electrons caught.

Here, between the detectors 613 and 614 and the sample 612, there is provided a mask 615 with the openings. The mask 615 is formed with an opening in a number of circular openings (for example, nine 615a to 615i) corresponding to the number of the electron beams. The center of each circular opening (for example, 615a and 615b) is precisely aligned with the axis of the corresponding electron beams (for example 610 and 611).

The preferred position of the mask 615 with the openings is derived through the following manner. Namely, assuming that the distance from the surface of the sample 612 to the detectors 613 and 614 is h, the distance from the surface of the sample 612 to the mask 615 is y, the radius (corresponding to the size of the detecting surface) of the detecting surface of the detectors 613 and 614 is a, the radius of the openings 615a to 615i of the mask is x, the distance between the irradiating points P_1 and P_2 of the electron beams is L, the position of the mask 615 is selected so that the values of x and y satisfy that x/a or y/h is in a range of 1.0 to 0.5 and a/L is in a range of 0 to 0.5 (refer to Fig. 42C).

For example, when the distance between the detectors 613 and 614 is substantially 0, a/L becomes 0.5. Therefore, in such a case, the preferred position of the mask 615 is determined so that x/a or y/h becomes 0.5. Therefore, the position of the mask 615 is selected to place the circular opening having a radius x being approximately one half of the radius x of the detecting surface at approximately an intermediate position (y/h = 0.5) of the distance between the surface of the sample 612 and the detectors 613 and 614.

It should be appreciated that Fig. 42(a) shows an example for the case where $a/L \fallingdotseq x/a \fallingdotseq y/h \fallingdotseq 0.5$. In the shown example, the backscattered electron 616 backscattered from the point P_1 toward the detector 613 and the backscattered electron 617 backscattered from the point P_2 toward the detector 614 can pass through the circular openings 615a and 615b. However, the backscattered electron from the adjacent irradiating region, such as the backscattered electron 618 backscattered from the point P_1 toward the detector 614, is blocked by the non-opening portion of the mask 615. Accordingly, with the shown embodiment, entry of the backscattered electron from the adjacent irradiating region to the detector can be positively eliminated to enhance the accuracy of detection.

Next, a fifth embodiment of the present invention will be discussed. The fifth embodiment is illustrated in Fig. 36, in which, the shown embodiment of the pattern inspection apparatus comprises a plurality of electron emitters arranged in a matrix fashion; each of the electron emitters include a fine electrode with a sharp headed tip end and a gate surrounding the tip end of the fine electrode, a converging electrode, a deflection electrode and a detector provided for each of the electron emitters. The electron beams are emitted from the electron emitters simultaneously and parallel to each other and irradiate the surface of the sample. The backscattered electron or the secondary electron are caught by the detecting surface of the detectors with respect to each of the electron beams. Based on the amount of the backscattered electrons or the secondary electrons, caught the condition of the surface of the sample is inspected. A plurality of tin tubes having a predetermined length are provided in the orientation aligning the longitudinal axes thereof parallel to the axes of the electron beams.

In the practical construction, as shown in Fig. 36, a bunch of thin tubes is arranged in the vicinity of all the detectors (only shown 620 and 621 in the drawing). As said tin tube, a lead glass tube of 20 $\mu m\phi$, which is used in an electron multiplier for MPC (micro-

channel plate) or so forth, is available. In the electron multiplier, the tube is slightly inclined relative to the axis of the electron beam so that the electrons collide on the inner periphery of the tube to provide energy corresponding to the potential of the inner wall for the backscattered electron. Conversely, in the shown embodiment, the tubes are provided precisely in alignment with the axis of the electron beam and no potential is provided for the inner wall.

With such an arrangement, the electron beams (typically 623, 624) can be irradiated on the sample 625 without any interference. On the other hand, only the backscattered electron having a reflecting angle smaller than or equal to a given angle is permitted to pass through the tube. Therefore, the backscattered electron from the adjacent irradiating region (which has too large a reflection angle) will never enter the tube. Therefore, interference of the backscattered electron from the adjacent irradiating region can be positively prevented. As can be appreciated, the reflection angular range to permit passing through the tube can be easily adjusted by selecting the diameter and length of the tubes.

Fig. 37 shows the sixth embodiment of the invention, in which the shown embodiment of the pattern inspection apparatus comprises a plurality of electron emitters arranged in a matrix fashion; each of the electron emitters includes a fine electrode with sharp headed tip end and a gate surrounding the tip end of the fine electrode, a converging electrode, a deflection electrode and a detector provided for each of the electron emitters. The electron beams are emitted from the electron emitters simultaneously and parallel to each other and irradiate the surface of the sample. The backscattered electron or the secondary electron are caught by the detecting surface of the detectors 632 with respect to each electron beam 630. Based on the amount of the backscattered electrons or the secondary electrons, caught the condition of the surface of the sample is inspected. The detectors are arranged between the converging and deflecting electrodes and the electron emitter.

Namely, as shown in Fig. 37, the detector 632 is positioned between the electron lens system, such as the converging electrode 630 or the deflection electrode 631 and the electron emitter.

With such construction, the backscattered electron 634 from the focus point of the electron lens system is deflected to be substantially parallel to the electron beam 635 in the principle of the convex lens and thus can easily reach the detector 632. Conversely, the backscattered electron 636 from the focus point of the adjacent electron lens system intersects with the axis of the electron beam 635 so as not to reach the detector 632. Therefore, with the shown arrangement, the precision in detection can be enhanced.

Figs. 38 to 41 show the seventh embodiment of the invention in which the shown embodiment of the pattern inspection apparatus comprises a plurality of electron emitters arranged in a matrix fashion; each of the electron emitters includes a fine electrode with sharp headed tip end and a gate surrounding the tip end of the fine electrode, a converging electrode, a deflection electrode and a detector provided for each of the electron emitters. The electron beams are emitted from the electron emitters simultaneously and parallel to each other and irradiate the surface of the sample. The backscattered electron or the secondary electron are caught by the detecting surface of the detectors with respect to each electron beam. Based on the amount of the backscattered electrons or the secondary electrons, caught the condition of the surface of the sample is inspected. The detected value of one of the detectors is processed by subtracting a value derived by multiplying respective signals of a plurality of surrounding detectors by a predetermined coefficient.

As shown in Fig. 38, the reference numerals 651 to 659 denote detectors provided corresponding to each electron emitter arranged in a matrix array. The detectors 651 to 659 are arranged in regular fine intervals. The detection signals PS_{651} to PS_{659} are provided to the signal processing section 660. The signal processing section 660 effects a predetermined signal processing to output corrected detection signals SS_{651} to SS_{659}.

Fig. 39 is an illustration showing one embodiment of the pattern inspection apparatus according to the invention;

Here, considering two adjacent detectors (for example, detectors 651 and 652 of Fig. 38), one of the detectors (for example 652) catch the backscattered electron 662 of the electron beam 661 from its own electron beam generating source and also catches the backscattered electron 664 of the electron beam 663 from the electron beam generating source corresponding to the adjacent detector 651. Then, by the presence of the backscattered electron 664, the S/N ratio of the detector 652 is degraded. The S/N ratio of the detector 652 can be further degraded by the influence of a plurality of adjacent electron beams.

The detection signals PS_{651} and PS_{652} of the detectors 651 and 652 are expressed by the following equations:

$$PS_{651} = SS_{651} + N_{652} \quad (1)$$
$$PS_{652} = SS_{652} + N_{651} \quad (2)$$

where SS_{651} is a value corresponding to the amount of backscattered electrons 665 of the electron beam 663, and SS_{652} is the value corresponding to the amount of backscattered electrons 662 of the electron beam 661, the values of which are the true values to be detected. N_{651} is the amount of backscattered electrons 664 of the electron beam 663 and N_{652} is the amount of electrons (not shown) of the electron beam 661, the values of which serve as causes for degradation of the S/N ratio by superimposing on the true

values.

N_{651} is proportional to the amount SS_{651} of the backscattered electron 665, as expressed by the following equation (3), and N_{652} is proportional to the amount SS_{652} of the backscattered electron 662, as expressed by the following equation (4). Namely, N_{651} and N_{652} will increase according to an increase in the backscattered electrons 665 and 662.

$$N_{651} = k \cdot SS_{651} \quad (3)$$

$$N_{652} = k \cdot SS_{652} \quad (4)$$

k in the foregoing equations (3) and (4) is a coefficient between N_{651} and SS_{651} and between N_{652} and SS_{652}. The amount of this coefficient k is determined according to the positional relationship between the detectors 651 and 652. For instance, then two detectors 651 and 652 are closely arranged, the k becomes large, and when distanced, k becomes smaller. It should be noted that the coefficient between N_{651} and SS_{651} is not coincident with that between N_{652} and SS_{652}, in the strict sense because of tolerances of the detectors. However, using a typical coefficient k derived on the basis of the average design data of the distance between the detectors and the size of the detecting surfaces will not create a problem.

Here, from the foregoing equations (1) and (2), the following equations (5) and (6) can be established.

$$PS_{651} = (1 - k^2) \cdot SS_{651} + k \cdot PS_{652} \quad (5)$$

$$PS_{652} = (1 - k^2) \cdot SS_{652} + k \cdot PS_{651} \quad (6)$$

Since k is less than 1,

$$PS_{651} \sim SS_{651} + k \cdot PS_{652} \therefore SS_{651} \sim PS_{651} - k \cdot PS_{652} \quad (7)$$

$$PS_{652} \sim SS_{652} + k \cdot PS_{651} \therefore SS_{652} \sim PS_{652} - k \cdot PS_{651} \quad (8)$$

Accordingly, in order to obtain the true signal SS_{651} by removing the noise component N_{652} from the detection signal PS_{651} of the detector 651, the value is derived by multiplying the detection signal value PS_{652} of the detector 652 by the coefficient k from the detection signal PS_{651} of the detector 651. similarly, in order to obtain the true signal SS_{652} by removing the noise component N_{651} from the detection signal PS_{652} of the detector 652, the value is derived by multiplying the detection signal value PS_{651} of the detector 651 by the coefficient k from the detection signal PS_{652} of the detector 652.

Fig. 40 is a block diagram showing a circuit for performing the foregoing subtraction process. In this example, as shown in Fig. 40(a), the shown embodiment of the circuit comprises two subtractors 670 and 671, and two multipliers 672 and 673. The multiplier 673 multiplies the detection signal PS_A by a coefficient k_A. The subtractor 671 subtracts the product obtained by the multiplier 673 from the detection signal PS_B to derive the true detection signal SS_B. Similarly, the multiplier 672 multiplies the detection signal PS_B by a coefficient k_B. The subtractor 670 subtracts the product obtained by the multiplier 672 from the detection signal PS_A to derive the true detection signal SS_A. In the preferred construction as shown in Fig. 40b, the subtractors are formed by operational amplifiers 680 and 681. The inverting inputs (-) of the operational amplifiers 680 and 681 are input via resistors R_A and R_B between respective inverting inputs (-) and the detection signal input terminals 682, 683; variable resistors VR_A and VR_B may be connected. By disposing the variable resistors VR_A and VR_B, the coefficients (k_A, k_B) can be set freely.

In the foregoing example, discussion has been provided for the case that two detection signals are processed. However, in the practical implementation of pattern inspection apparatus according to the present invention, a greater number of detection signals have to be processed.

For example, Fig. 38 shows the example in which 9 detectors 651 to 659 are provided. In this example, several groups are formed with the detectors having a positional relationship to have equal coefficients with respect to the specific detector (for example, detector 655 of Fig. 38) for which the true detection signal is to be obtained. In the shown example, the detectors 652, 654. 656 and 658 form one group that will be hereafter referred to as group α, and the detectors 651, 653, 657 and 659 form another group hereafter referred to as group β. The detection signals of the detectors in each group are summed. The sum thus calculated is multiplied with the coefficient common for the detectors in the group. Namely, in the shown case, the sum of the detection signals in the group α is multiplied by the coefficient $k\alpha$. The product thus derived is subtracted from the detector signal PS_{655} of the detector 655 to derive the true detector signal value. This process is expressed by the following equation (9):

$$SS_{655} = PS_{655} - k\alpha \cdot \Sigma PS\alpha - k\beta . \Sigma PS\beta \quad (9)$$

where $\Sigma PS\alpha = PS_{652} + PS_{654} + PS_{656} + PS_{658}$

$\Sigma PS\beta = PS_{651} + PS_{653} + PS_{657} + PS_{659}$

Namely, in the foregoing equation (9), the common equations $k\alpha$ and $k\beta$ are used for the detector signals of the detectors positioned respectively at equal distance from the specific detector, for which the true detection signal SS_{655} is to be derived.

If different coefficients are used, the following equation (10) is established:

$$SS_{655} = PS_{655} - k_{651-655} \cdot PS_{651} - k_{652-655} \cdot PS_{652} - k_{653-655} \cdot PS_{653} - k_{654-655} \cdot PS_{654} \ldots - k_{659-655} \cdot PS_{659} \quad (10)$$

Note, the suffix, such as 651-655 represents the coefficient between the detectors 651 and 655.

Further discussion will be provided about the enhancement of the S/N ratio with reference to Fig. 41. The detection signal in the case of no pattern, at which the backscattered electron from the irradiating region is minimum, is illustrated by a single bar graph 690. Conversely, the detection signal in the case that the pattern is present and thus the amount of the back-

scattered electron is large, is illustrated by a double line graph 691. In addition, the hatched areas of the bar graph represent the true detection signal values and respectively expressed by S_{OFF} (pattern absent) and S_{ON} (pattern present).

Now, consideration is provided for the case that the pattern is present. In this case, assuming that the backscattered electron of the adjacent electron beam is zero, the signal S_{ON} corresponding to the hatched portion of the bar graph 691 (or 692), namely the true detection signal, can be obtained when the backscattered electron of the adjacent electron beam is included in the detection signal as the noise component. In this case, when all of the adjacent irradiating regions have patterns, the maximum noise component (N_{max}) should be superimposed on the true detection signal. On the other hand, when all of the adjacent irradiating regions have no patterns, the minimum noise component (N_{min}) is superimposed on the true detection signal. The following equation expresses the S/N ratio of the case of Fig. 41.

$$S/N = (S_{ON} - S_{OFF})/(S_{ON} + "N" - S_{ON}) \quad (11)$$

In the foregoing equation "N" is to be replaced for N_{max} to N_{min}. The greater N value will degrade the S/N ratio. Therefore, by setting an optimum coefficient k (it is desirable to vary depending upon the presence and absence of the pattern) with respect to the adjacent beams to subtract the product ($k \cdot S_{ON}$) of the coefficient k and the detection signal value of the adjacent beam from the detection signal value to compensate for the noise component, the S/N ratio can be enhanced.

It should be noted that the electron beam scanning device is applicable not only to the electron beam drawing system and electron beam inspection system but also to a plane display system or a wide variety of electron beam utilizing products.

With the foregoing embodiment, the interference of backscattered electrons of adjacent beams can be positively prevented or successfully compensated for to obtain an enhanced S/N ratio.

Although the invention has been illustrated and described with respect to an exemplary embodiment thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omissions and additions may be made therein and thereto, without departing from the spirit and scope of the present invention. Therefore, the present invention should not be understood as limited to the specific embodiment set out about but includes all possible embodiments that are within the scope encompassed and equivalents thereof with respect to the features set out in the appended claims.

Claims

1. A pattern inspection apparatus comprising:

   electron beam generating means including an electron gun for generating at least one electron beam accelerated, and converged into a predetermined diameter and irradiating an inspecting sample;

   movable support means for supporting said inspecting sample;

   detecting means including a plurality of electron detecting elements arranged on a plane for detecting an electron containing a construction information of said inspecting sample; and

   signal processing means for processing information output from respective said electron detecting elements of said detecting means simultaneously or in parallel formation.

2. A pattern inspection apparatus as set forth in claim 1, wherein said electron beam generating means includes a plurality of electron guns simultaneously generating electron beams.

3. A pattern inspection apparatus as set forth in claim 2, wherein said plurality of electron beams irradiate a plurality of irradiating regions on said inspecting sample.

4. A pattern inspection apparatus as set forth in claim 1, wherein said electron beam generating means has a drive means for driving said electron beam generating means <u>per se</u> within a plane parallel to a surface of said inspecting sample.

5. A pattern inspection apparatus as set forth in claim 1, wherein said detecting means includes said plurality of electron detecting elements arranged in parallel relationship with a plane of said inspection sample and in alignment in one dimensional direction.

6. A pattern inspection apparatus as set forth in claim 1, wherein said detecting means includes said plurality of electron detecting elements arranged in parallel relationship with a plane of said inspection sample and in alignment in two dimensional directions.

7. A pattern inspection apparatus as set forth in claim 1, wherein said detection signal processing means includes a processing means for performing an image processing for said detected information.

8. A pattern inspection apparatus as set forth in claim 1, wherein a plurality of said electron beam generating means are formed in predetermined common or different semiconductor substrates, to which at least an electron emitter, a converging electrode and a deflection electrode are formed in

laminating fashion.

9. A pattern inspection apparatus as set forth in claim 2, wherein respective said electron beams are formed into pulses respectively having different periods.

10. A pattern inspection apparatus as set forth in claim 2, wherein said electron beams are formed into pulses having mutually different pulse widths.

11. A pattern inspection apparatus as set forth in claim 2, wherein said electron beams are modulated electron beams modulated by modulation signals having mutually distinct signal patterns.

12. A pattern inspection apparatus as set forth in claim 9, wherein said detecting means corrects information relating to the construction of said inspecting sample irradiated by said electron beam in synchronism with pulse periods of respective electron beams.

13. A pattern inspection apparatus as set forth in claim 10, wherein said detecting means detects respective the pulse widths of said electron beams and processes information relating to the construction of said inspecting sample irradiated by said electron beams.

14. A pattern inspection apparatus as set forth in claim 11, wherein said detecting means detects the pulse widths of modulated electron beams and processes information relating to the construction of said inspecting sample irradiated by said electron beams.

15. A pattern inspection apparatus as set forth in claim 11, wherein said signal processing means processes said respective electron beams formed into pulses having mutually different pulse widths in a time division multiplexing manner.

16. A pattern inspection apparatus as set forth in claim 13, wherein said signal processing means includes an electron flow detecting means and a signal discriminating means for discriminating information relating to the construction at respective said irradiating regions from the output signal of said electron flow detecting means using said modulation signal as a reference signal.

17. A pattern inspection apparatus as set forth in claim 15 that further comprises an electron beam scanning means comprising an electrostatic deflection electrode.

18. A pattern inspection apparatus as set forth in claim 17, wherein said electron beam scanning means includes a mechanical scanning means for shifting at least one of the electron beam generating means and said inspecting sample.

19. A pattern inspection apparatus as set forth in claim 18, wherein said mechanical scanning means includes a fine shifting stage that is shifted at least one direction by the actuation of a piezoelectric oscillator.

20. A pattern inspection apparatus as set forth in claim 1, wherein said electron beam generating means comprises an electron beam emitting means for uniformly emitting an electron beam within a predetermined range, fine openings arranged opposite respective irradiating range of said inspecting sample for introducing an electron beam from said electron emitting means, and a converging electrode for converging a respective introduced electron beam.

21. A pattern inspection apparatus as set forth in claim 11, wherein said modulation signals are pulse signals having a mutually different pulse widths and mutually identical repeating periods.

22. A pattern inspection apparatus as set forth in claim 11, wherein said modulation signals are pulse signals having mutually identical repeating periods and mutually different pulse peak timings.

23. A pattern inspection apparatus comprising:

a plurality of electron emitters arranged on a common substrate or a plurality of individual substrates arranged on the same plane; each electron emitter comprising:

an extracting electrode for extracting charged particle beams having a beam current corresponding to an electrode voltage from said electron emitter;

a converging electrode or a converging coil providing a converging ratio for said charged particle beam corresponding to an electrode voltage or an energization current;

optionally provided with a deflection electrode or a deflection coil providing a deflection angle for said charged particle beam corresponding to an electrode voltage or an energization current

detectors for detecting all of or part of respective said secondary electron or backscattered electron from the surface of an inspection sample exposed to the converged and deflected charged particle beam or transmission electron passing through said inspecting sample; and

adjusting means for adjusting all of or part of respective said electrode voltages or energiza-

tion voltages to be applied to said extraction electrode, said converging electrode or converging coil, and said deflection electrode or deflection coil.

24. A pattern inspection apparatus as set forth in claim 23, wherein said adjusting means selectively adjusts the breaking and connecting of respective elements per se or wiring connected said elements of a resistor network.

25. A pattern inspection apparatus as set forth in claim 24, wherein said elements of said resistor network comprise transistors.

26. A pattern inspection apparatus as set forth in claim 23 that further comprises an arithmetic means for measuring fluctuation spot diameters or deflection angles of charged particle beams after convergence and deflection on the basis of the signal from said detector, and calculating correction amount for correcting all of or part of respective said electrode voltages or energization currents of said extraction electrode, said converging electrode or converging coil and said deflection electrode or deflection coil.

27. A pattern inspection apparatus comprising:
a plurality of electron emitters each including a fine electrode having a sharp headed tip end and a gate surrounding said tip end; said electron emitters being arranged in the form of a matrix;
a converging electrode, an optional deflection electrode and a detector provided for each of said electron emitters;
said electron emitters irradiating electron beams parallel to each other and simultaneously on an inspecting sample;
said detector catching a backscattered electron or a secondary electron from the surface of said inspecting sample with respect to each of said electron beams at detection surfaces;
inspection of the condition of the surface of said inspecting sample is performed on the basis of the amount of caught backscattered electron or caught secondary electron, and
a mask having openings having predetermined internal diameters and arranged to align the center thereof with the axes of said electron beams at a position between the surface of said inspection sample and said detection surfaces and distanced from said surface of said inspecting sample and said detecting surface in a magnitude derived based on the distance between said surface of said inspecting sample and said detecting surface and the size of said detecting surface.

28. A pattern inspection apparatus comprising:
a plurality of electron emitters, each including a fine electrode having a sharp headed tip end and a gate surrounding said tip end; said electron emitters being arranged in the form of a matrix;
a converging electrode, an optional deflection electrode and a detector provided for each of said electron emitters;
said electron emitters irradiating electron beams parallel to each other and simultaneously on an inspecting sample;
said detector catching a backscattered electron or a secondary electron from the surface of said inspecting sample with respect to each of said electron beams at detection surfaces;
inspection of the condition of the surface of said inspecting sample is performed on the basis of the amount of caught backscattered electrons or caught secondary electrons, and
a plurality of thin tubes respectively having a predetermined length being arranged so that the longitudinal axes of said thin tubes extend parallel to the beam axes of said electron beams.

29. A pattern inspection apparatus comprising:
a plurality of electron emitters, each including a fine electrode having a sharp headed tip end and a gate surrounding said tip end; said electron emitters being arranged in the form of a matrix;
a converging electrode, an optional deflection electrode and a detector provided for each of said electron emitters;
said electron emitters irradiating electron beams parallel to each other and simultaneously on an inspecting sample;
said detector catching a backscattered electron or a secondary electron from the surface of said inspecting sample with respect to each of said electron beams at detection surfaces;
inspection of the condition of the surface of said inspecting sample is performed on the basis of the amount of caught backscattered electrons or caught secondary electrons, and
said detecting beam arranged between said converging and deflecting electrodes and said electron emitters.

30. A pattern inspection apparatus comprising:
a plurality of electron emitters, each including a fine electrode having a sharp headed tip end and a gate surrounding said tip end; said electron emitters being arranged in the form of a matrix;
a converging electrode, an optional deflection electrode and a detector provided for each of said electron emitters;
said electron emitters irradiating electron beams parallel to each other and simultaneously on an inspecting sample;

said detector catching a backscattered electron or a secondary electron from the surface of said inspecting sample with respect to each of said electron beams at detection surfaces;

inspection of the condition of the surface of said inspecting sample is performed on the basis of the amount of caught backscattered electrons or caught secondary electrons, and

the detection value of one of the specific detectors being corrected by subtracting a value derived by multiplying a predetermined coefficient for signals indicative of detection values of a plurality of other detectors position around said specific detector for which a correction of the detection value is made, from the output of said specific detector.

31. An electron beam apparatus comprising:

a plurality of electron emitters arranged on a common substrate or a plurality of individual substrates arranged on the same plane; each electron emitter comprising:

an extracting electrode for extracting charged particle beams having a beam current corresponding to an electrode voltage from said electron emitter;

a converging electrode or a converging coil providing a converging ratio for said charged particle beam corresponding to an electrode voltage or an energization current

optionally provided with a deflection electrode or a deflection coil providing a deflection angle for said charged particle beam corresponding to an electrode voltage or an energization current

detectors for detecting all of or part of respective said secondary electron or backscattered electron from the surface of an inspection sample exposed to the converged and deflected charged particle beam or transmission electron passing through said inspecting sample; and

adjusting means for adjusting all of or part of respective said electrode voltages or energization voltages to be applied to said extraction electrode, said converging electrode or converging coil, and said deflection electrode or deflection coil.

32. An electron beam apparatus comprising:

a plurality of electron emitters each including a fine electrode having a sharp headed tip end and a gate surrounding said tip end; said electron emitters being arranged in the form of a matrix;

a converging electrode, an optional deflection electrode and a detector provided for each of said electron emitters;

said electron emitters irradiating electron beams parallel to each other and simultaneously on an inspecting sample;

said detector catching a backscattered electron or a secondary electron from the surface of said inspecting sample with respect to each of said electron beams at detection surfaces;

inspection of the condition of the surface of said inspecting sample is performed on the basis of the amount of caught backscattered electron or caught secondary electron, and

a mask having openings having predetermined internal diameters and arranged to align the center thereof with the axes of said electron beams at a position between the surface of said inspection sample and said detection surfaces and distanced from said surface of said inspecting sample and said detecting surface in a magnitude derived based on the distance between said surface of said inspecting sample and said detecting surface and the size of said detecting surface.

33. An electron beam apparatus comprising:

a plurality of electron emitters, each including a fine electrode having a sharp headed tip end and a gate surrounding said tip end; said electron emitters being arranged in the form of a matrix;

a converging electrode, an optional deflection electrode and a detector provided for each of said electron emitters;

said electron emitters irradiating electron beams parallel to each other and simultaneously on an inspecting sample;

said detector catching a backscattered electron or a secondary electron from the surface of said inspecting sample with respect to each of said electron beams at detection surfaces;

inspection of the condition of the surface of said inspecting sample is performed on the basis of the amount of caught backscattered electrons or caught secondary electrons, and

a plurality of thin tubes respectively having a predetermined length being arranged so that the longitudinal axes of said thin tubes extend parallel to the beam axes of said electron beams.

34. An electron beam inspection apparatus comprising:

a plurality of electron emitters, each including a fine electrode having a sharp headed tip end and a gate surrounding said tip end; said electron emitters being arranged in the form of a matrix;

a converging electrode, an optional deflection electrode and a detector provided for each of said electron emitters;

said electron emitters irradiating electron beams parallel to each other and simultaneously on an inspecting sample;

said detector catching a backscattered

electron or a secondary electron from the surface of said inspecting sample with respect to each of said electron beams at detection surfaces;

inspection of the condition of the surface of said inspecting sample is performed on the basis of the amount of caught backscattered electrons or caught secondary electrons, and

said detecting beam arranged between said converging and deflecting electrodes and said electron emitters.

35. An electron beam apparatus comprising:

a plurality of electron emitters, each including a fine electrode having a sharp headed tip end and a gate surrounding said tip end; said electron emitters being arranged in the form of a matrix;

a converging electrode, an optional deflection electrode and a detector provided for each of said electron emitters;

said electron emitters irradiating electron beams parallel to each other and simultaneously on an inspecting sample;

said detector catching a backscattered electron or a secondary electron from the surface of said inspecting sample with respect to each of said electron beams at detection surfaces;

inspection of the condition of the surface of said inspecting sample is performed on the basis of the amount of caught backscattered electrons or caught secondary electrons, and

the detection value of one of the specific detectors being corrected by subtracting a value derived by multiplying a predetermined coefficient for signals indicative of detection values of a plurality of other detectors position around said specific detector for which a correction of the detection value is made, from the output of said specific detector.

Fig.1(a)

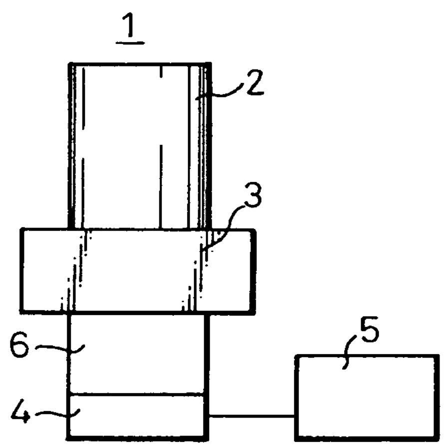


Fig.1(b)

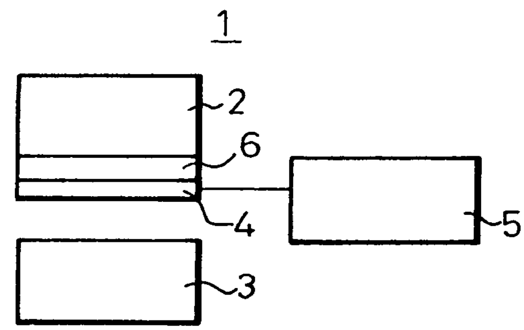


Fig. 2

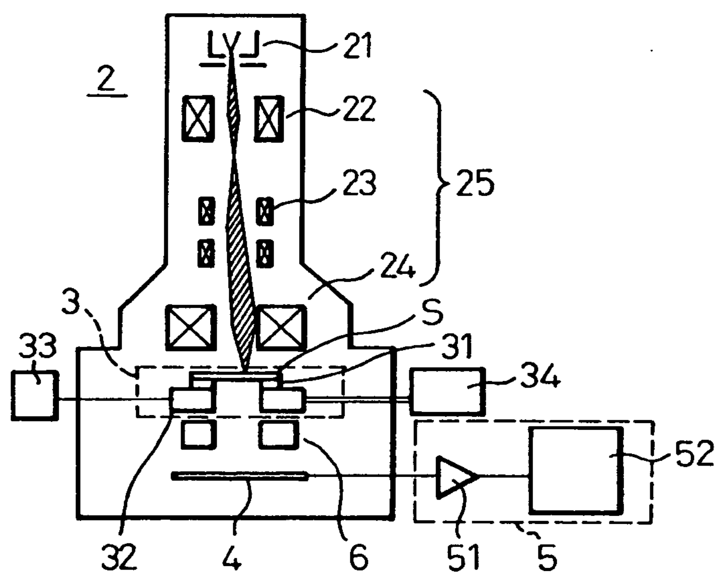


Fig. 3(a)

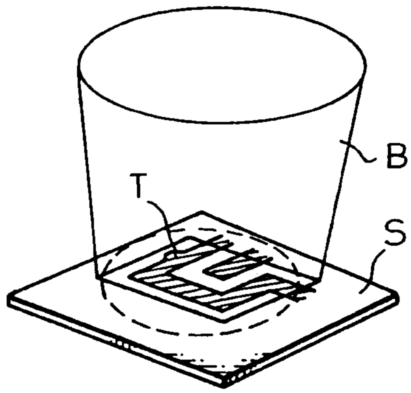


Fig. 3(b)

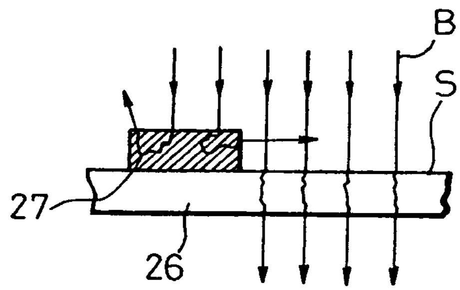


Fig. 3(c)

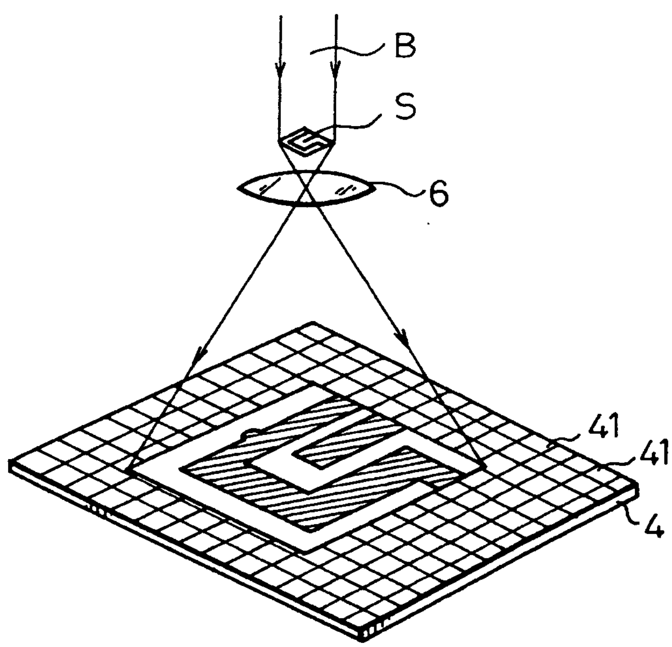


Fig. 4

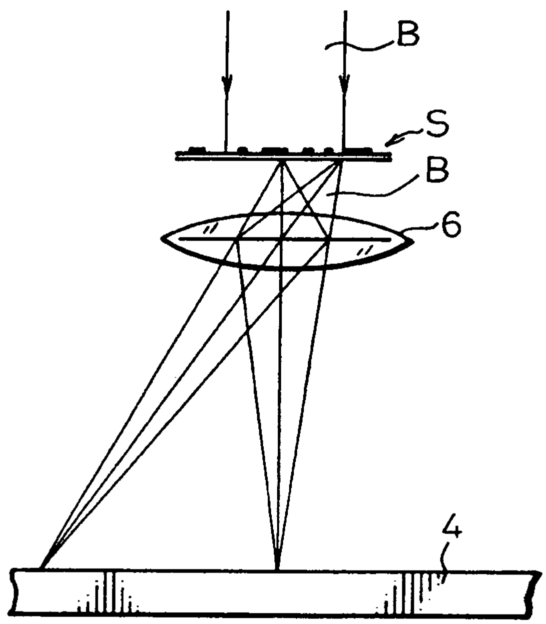

B
S
B
6
4

Fig. 5

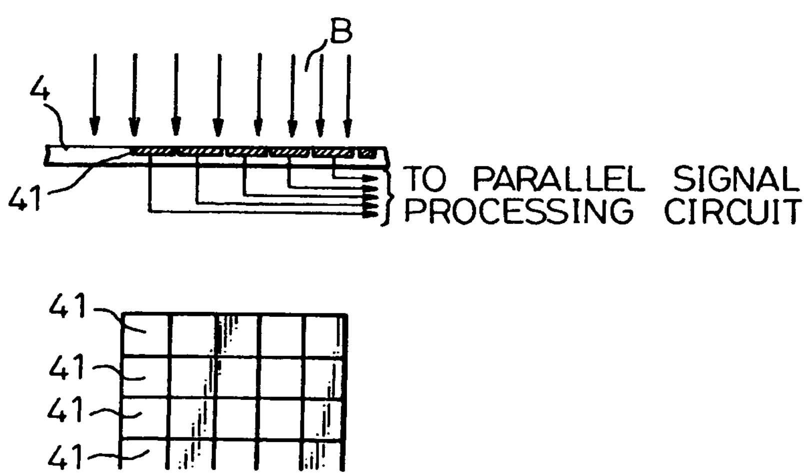

B
4
41
TO PARALLEL SIGNAL PROCESSING CIRCUIT
41
41
41
41

Fig. 6

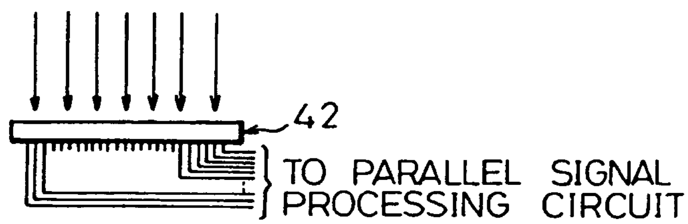


Fig. 7

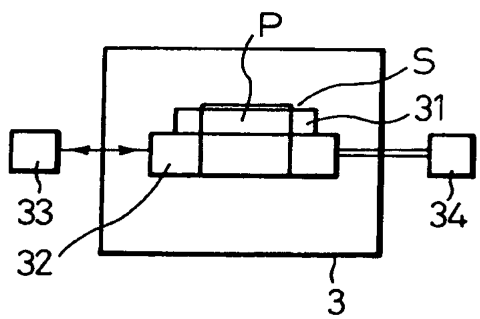


Fig.8

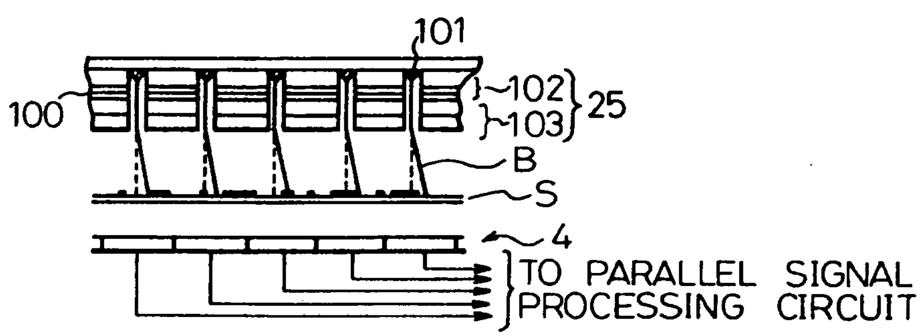


Fig. 9(a)

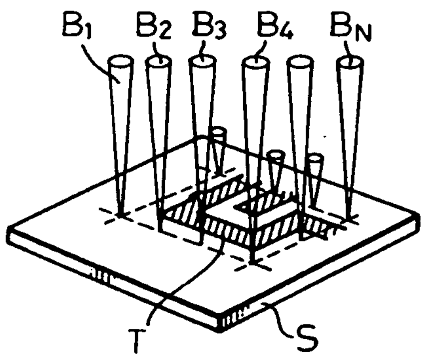


Fig.9(b)

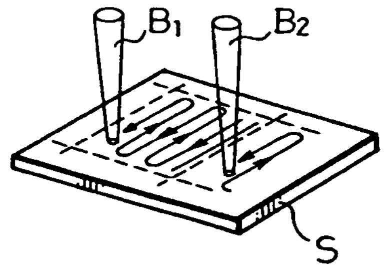


Fig.10(a)

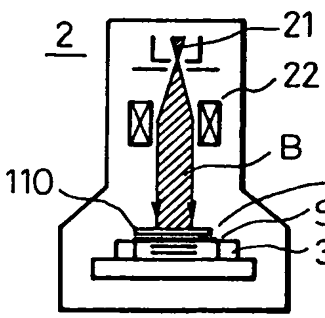


Fig.10(b)

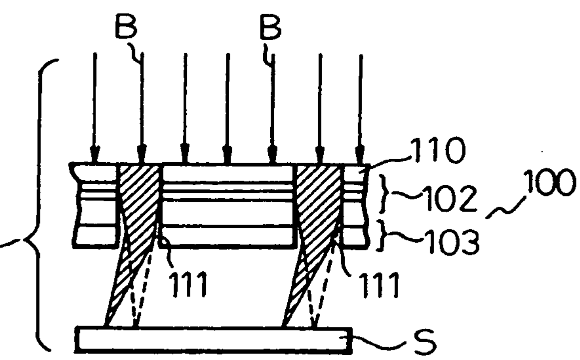


Fig.11

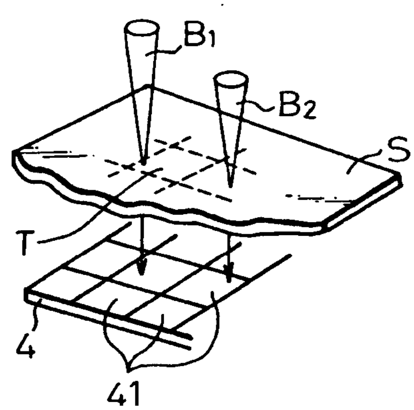


Fig.12

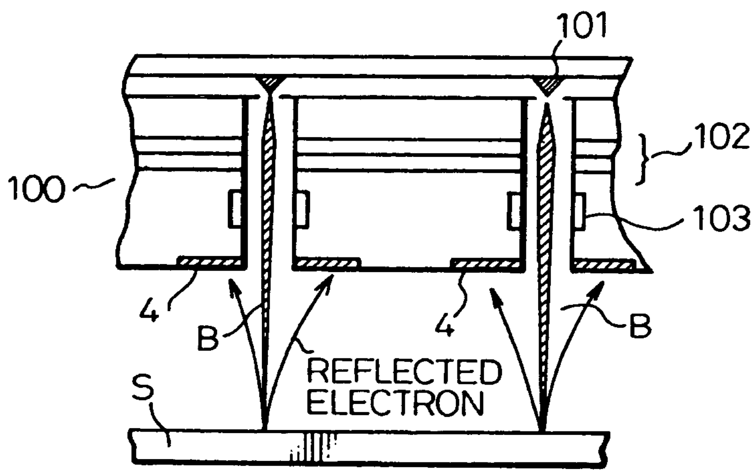


Fig.13

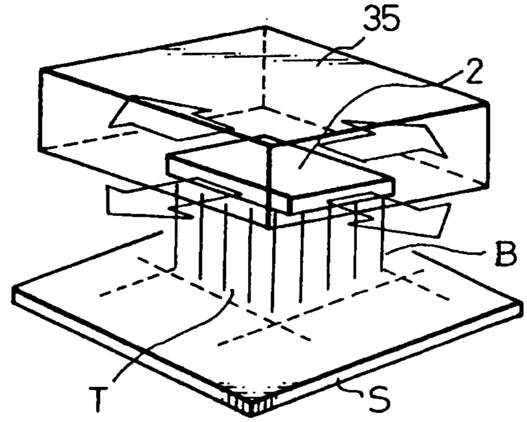


Fig.14

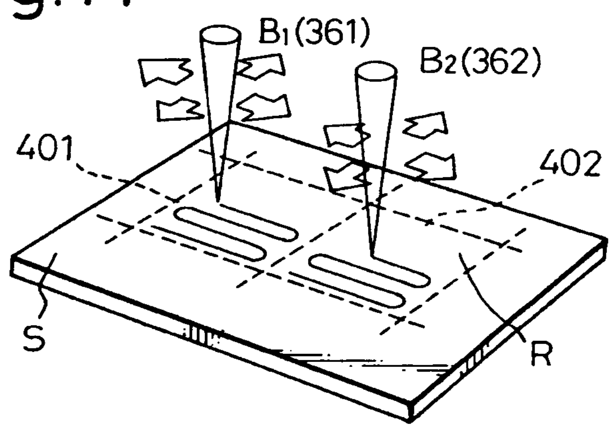


Fig.15

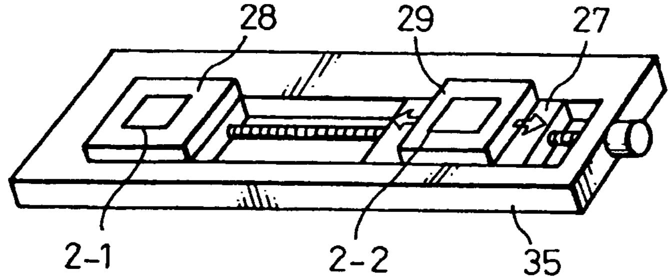


Fig.16

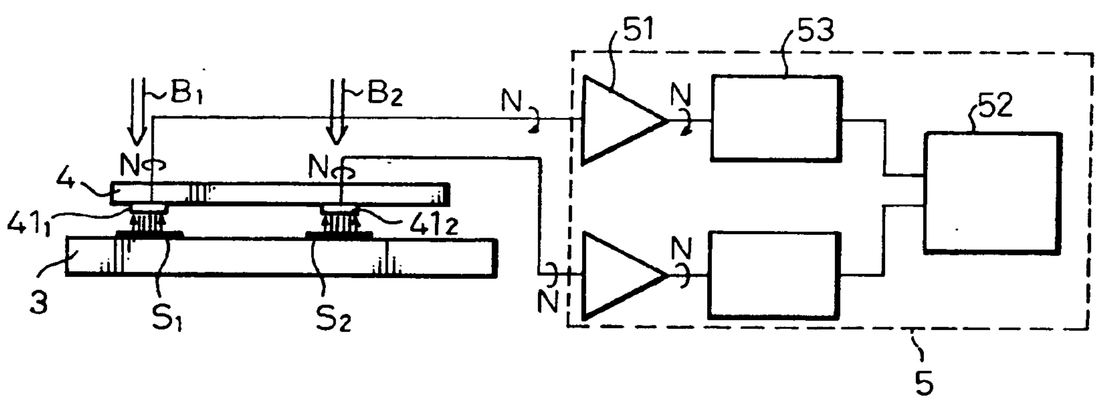


Fig. 17

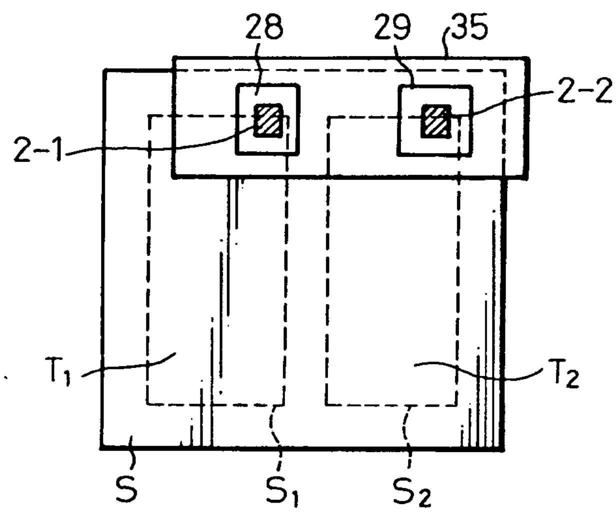


Fig.18

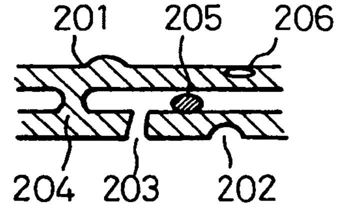


Fig.19

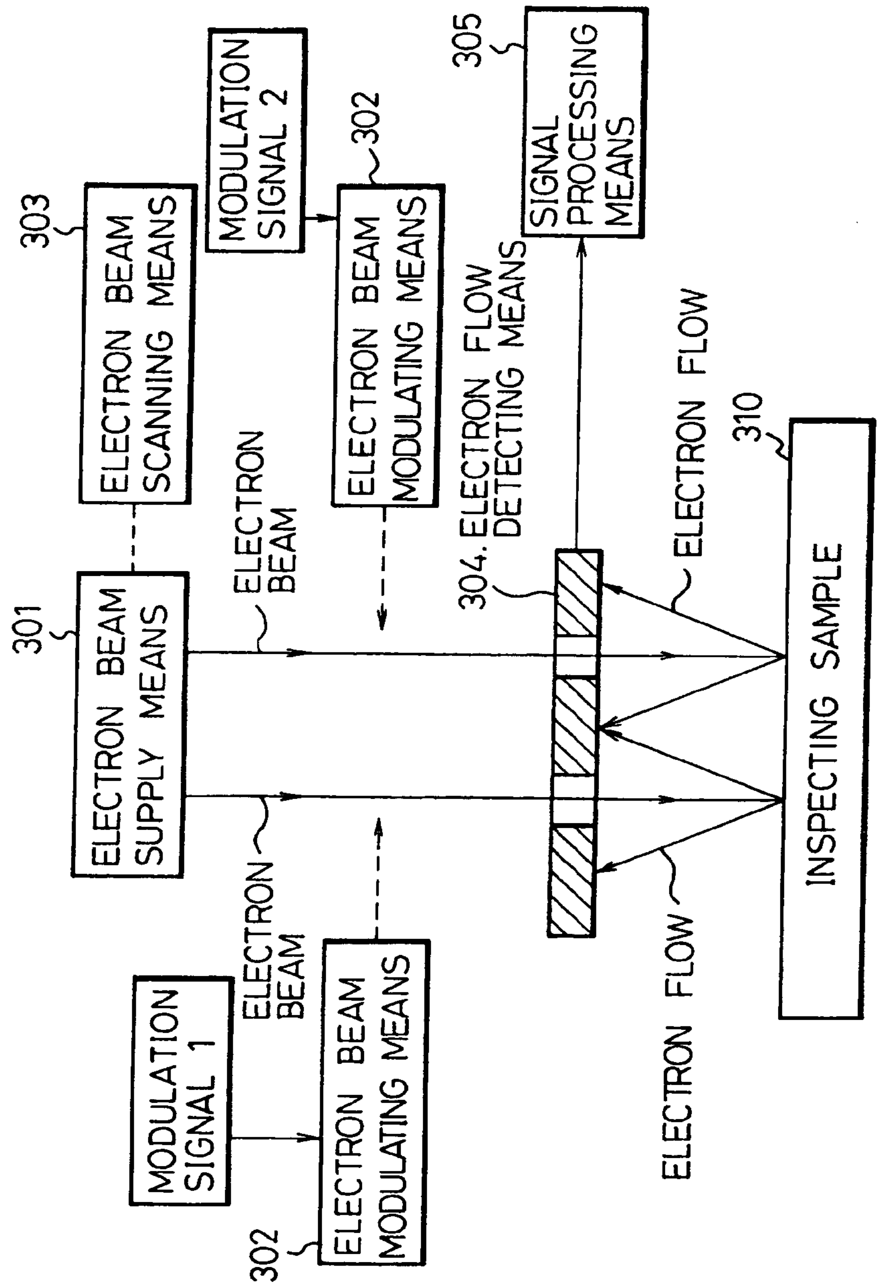

ELECTRON BEAM SUPPLY MEANS
301
ELECTRON BEAM SCANNING MEANS
303
MODULATION SIGNAL 2
ELECTRON BEAM MODULATING MEANS
302
SIGNAL PROCESSING MEANS
305
ELECTRON BEAM
ELECTRON BEAM
304, ELECTRON FLOW DETECTING MEANS
ELECTRON FLOW
ELECTRON FLOW
310
INSPECTING SAMPLE
MODULATION SIGNAL 1
ELECTRON BEAM MODULATING MEANS
302

Fig. 20

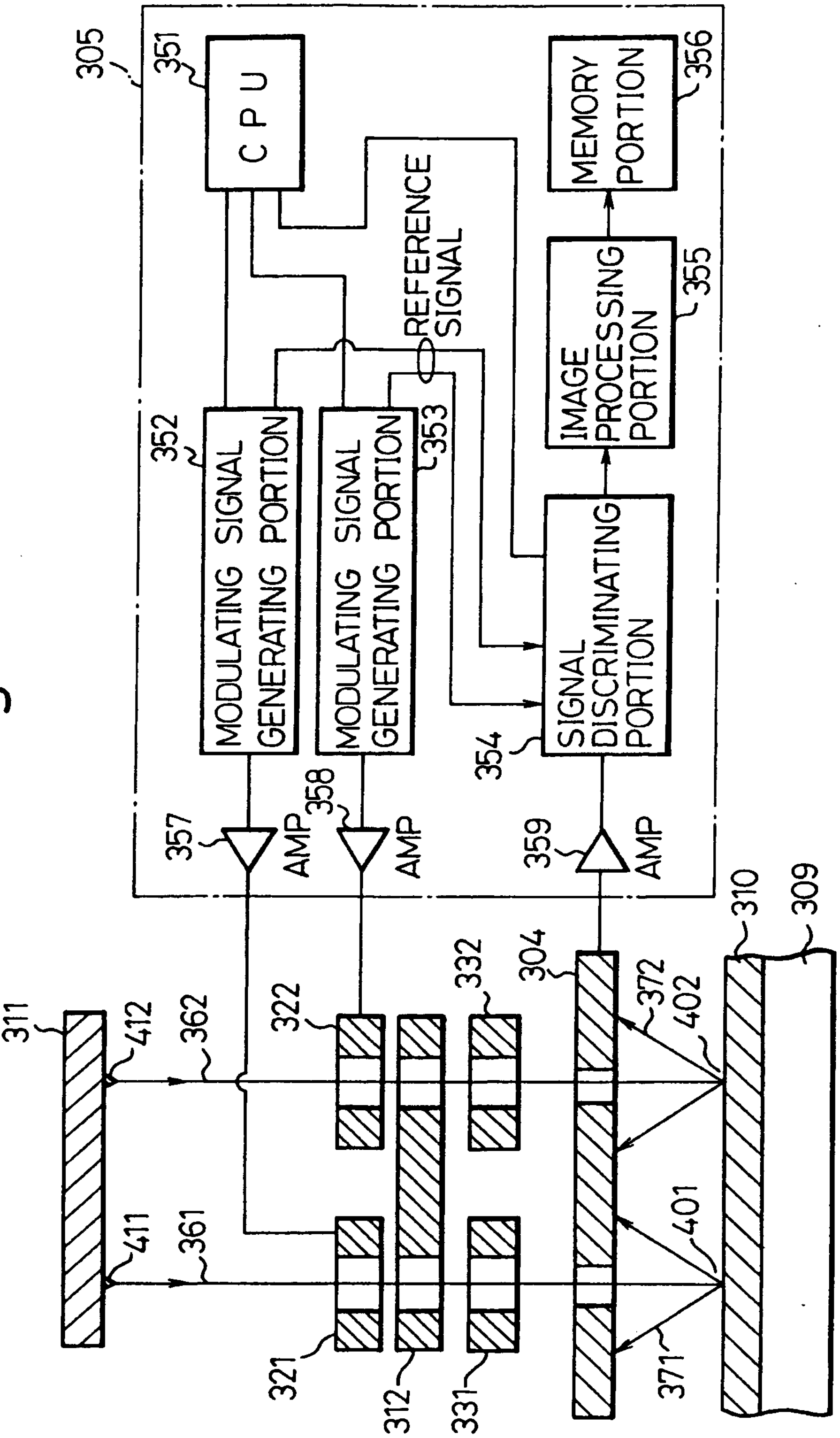

305
351
C P U
REFERENCE SIGNAL
MEMORY PORTION
356
IMAGE PROCESSING PORTION
355
352
MODULATING SIGNAL GENERATING PORTION
MODULATING SIGNAL GENERATING PORTION
353
SIGNAL DISCRIMINATING PORTION
354
357
AMP
358
AMP
359
AMP
311
412
362
322
332
304
372
402
310
309
411
361
401
321
312
331
371

Fig. 21(a)

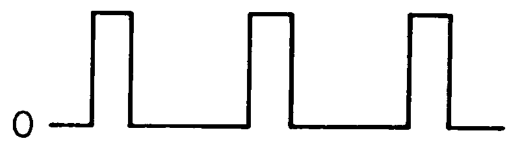


Fig. 21(b)

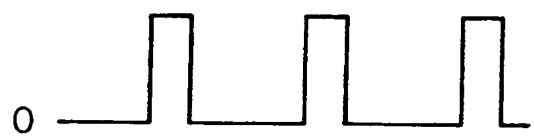


Fig. 21(c)

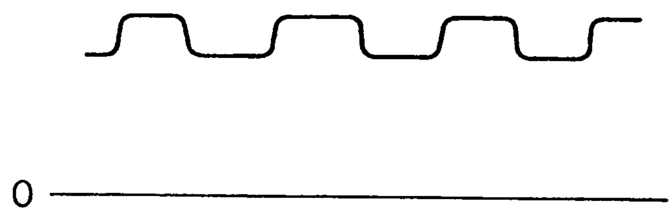


Fig. 21(d)

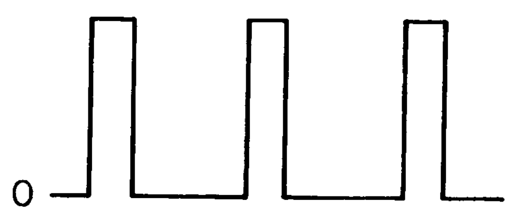


Fig. 21(e)

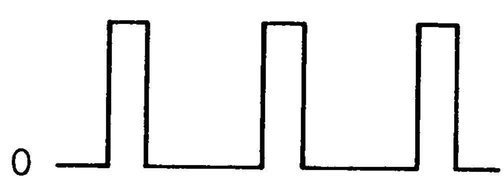


Fig. 22

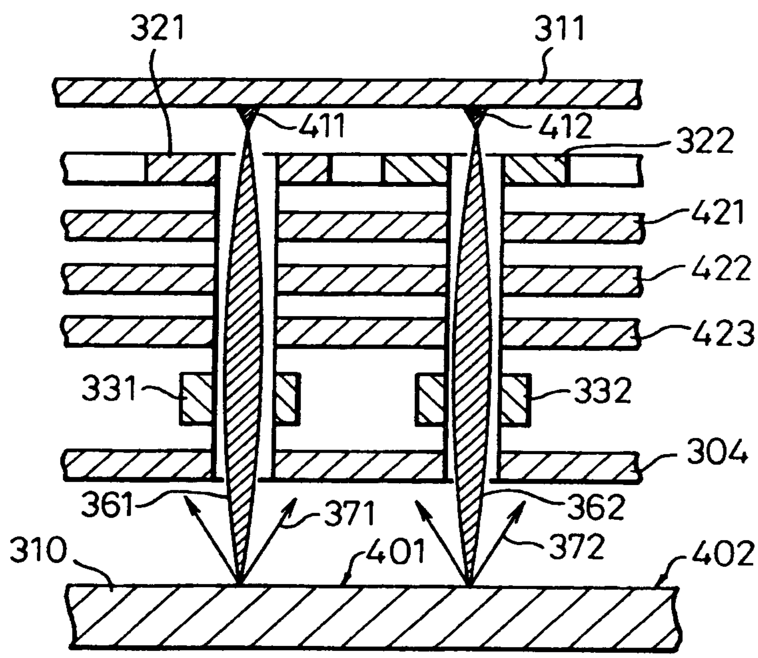
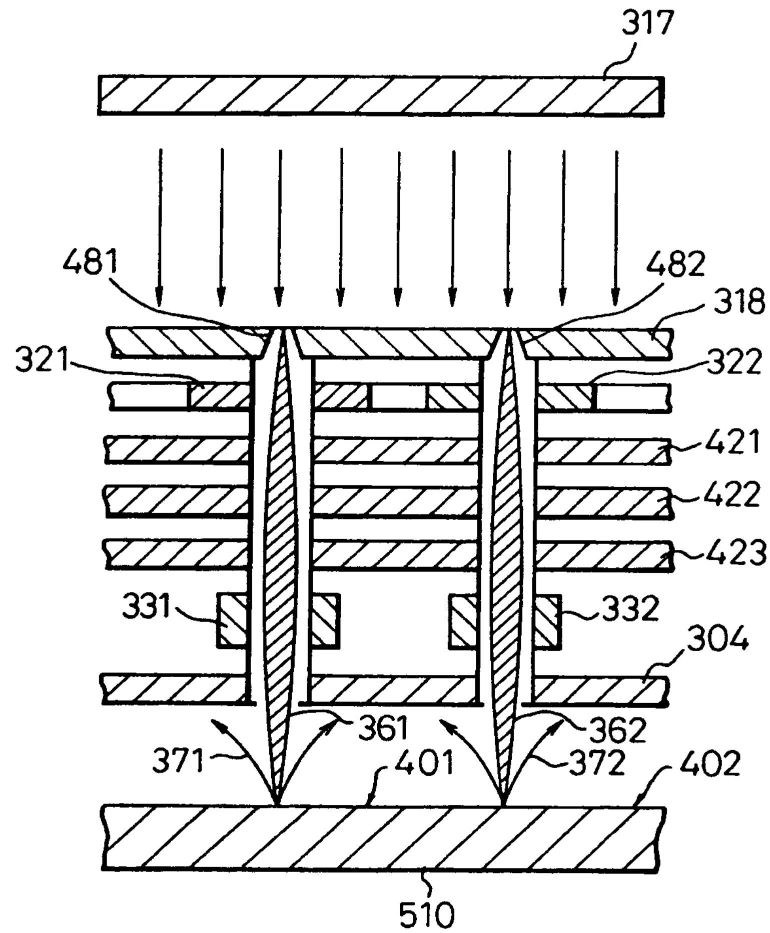

321
311
411
412
322
421
422
423
331
332
304
361
371
362
372
310
401
402

Fig. 23


317
481
482
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321
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421
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423
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332
304
361
362
371
401
372
402
510

Fig. 24

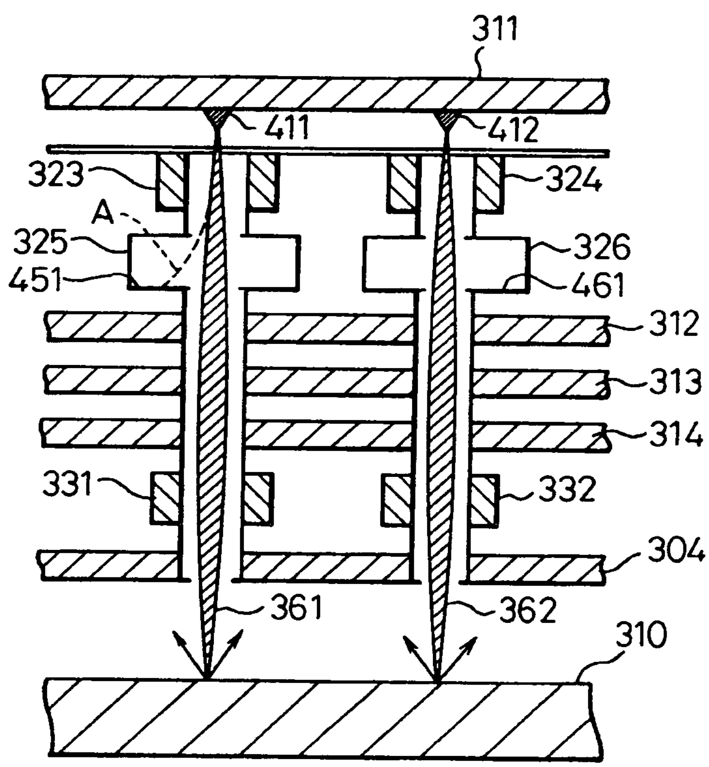

311
411
412
323
324
A
325
326
451
461
312
313
314
331
332
304
361
362
310

Fig. 25

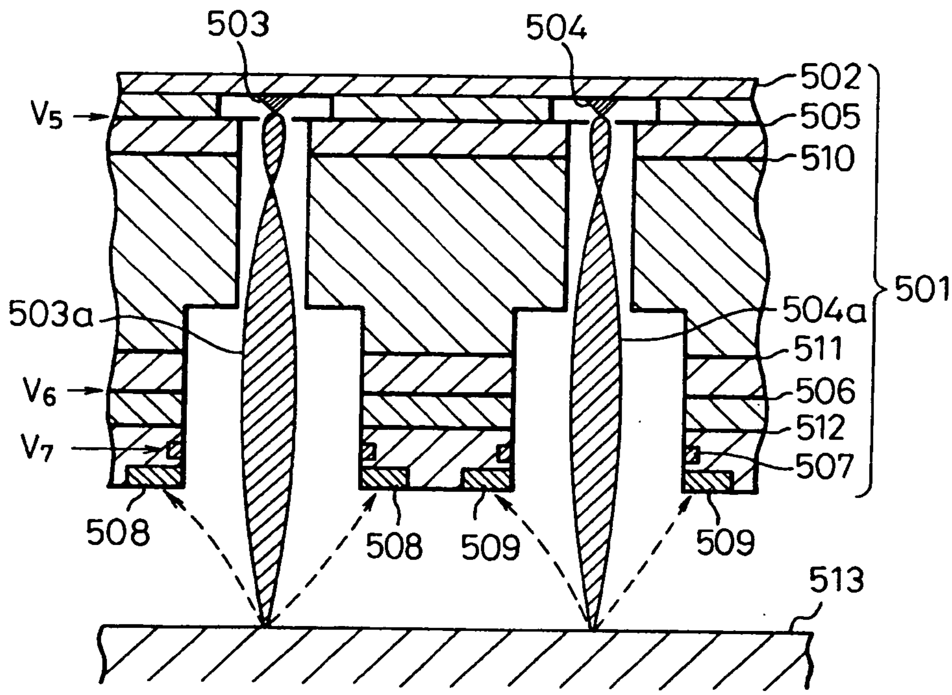

503
504
502
V5
505
510
503a
504a
501
511
V6
506
512
V7
507
508
508
509
509
513

Fig. 26

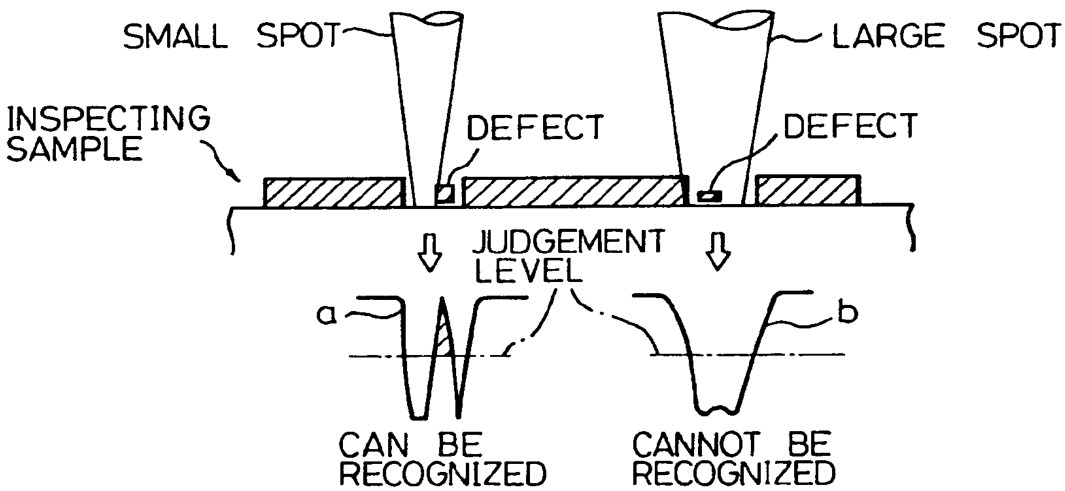

SMALL SPOT
LARGE SPOT
INSPECTING SAMPLE
DEFECT
DEFECT
JUDGEMENT LEVEL
a
b
CAN BE RECOGNIZED
CANNOT BE RECOGNIZED

Fig. 27

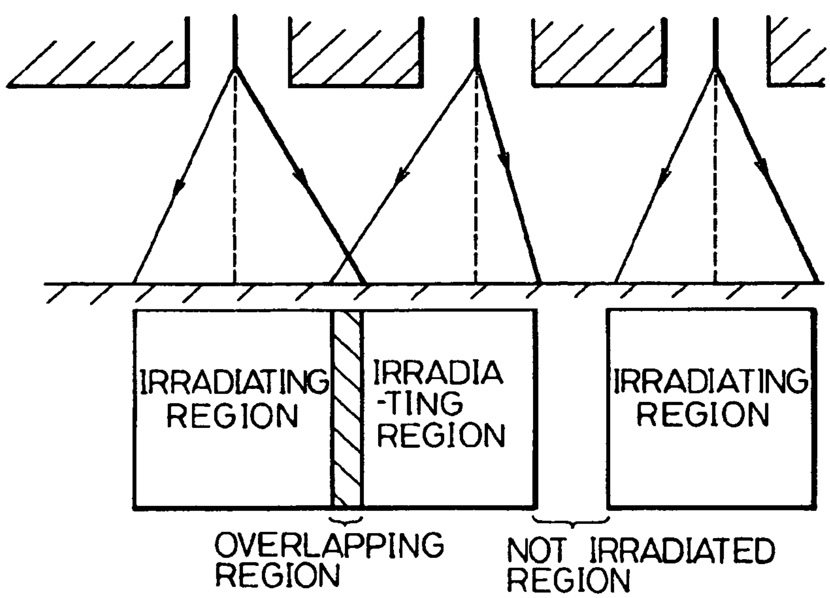

IRRADIATING REGION
IRRADIA -TING REGION
IRRADIATING REGION
OVERLAPPING REGION
NOT IRRADIATED REGION

Fig. 28

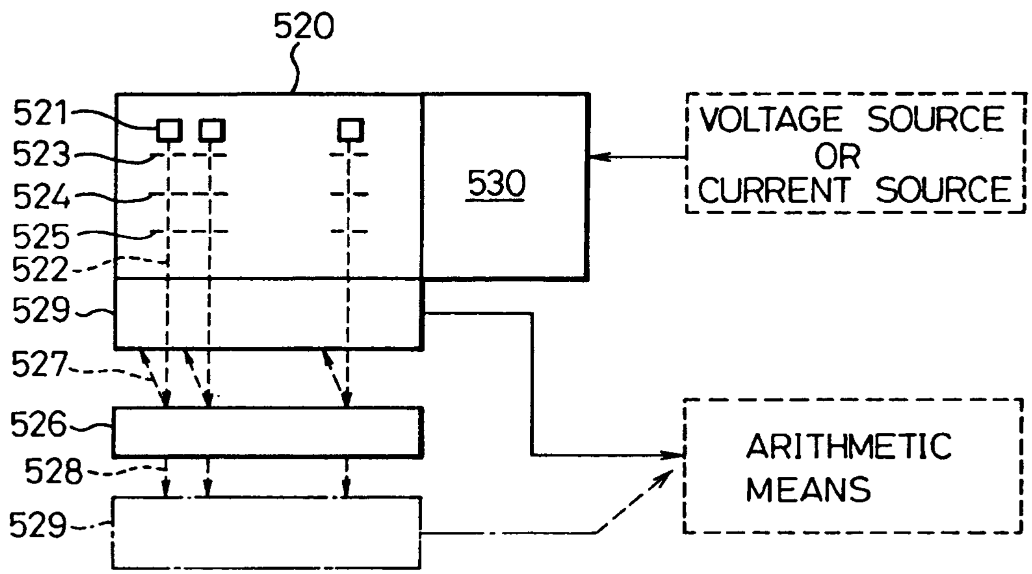

520
521
523
524
525
522
529
527
526
528
529
530
VOLTAGE SOURCE
OR
CURRENT SOURCE
ARITHMETIC
MEANS

Fig. 29

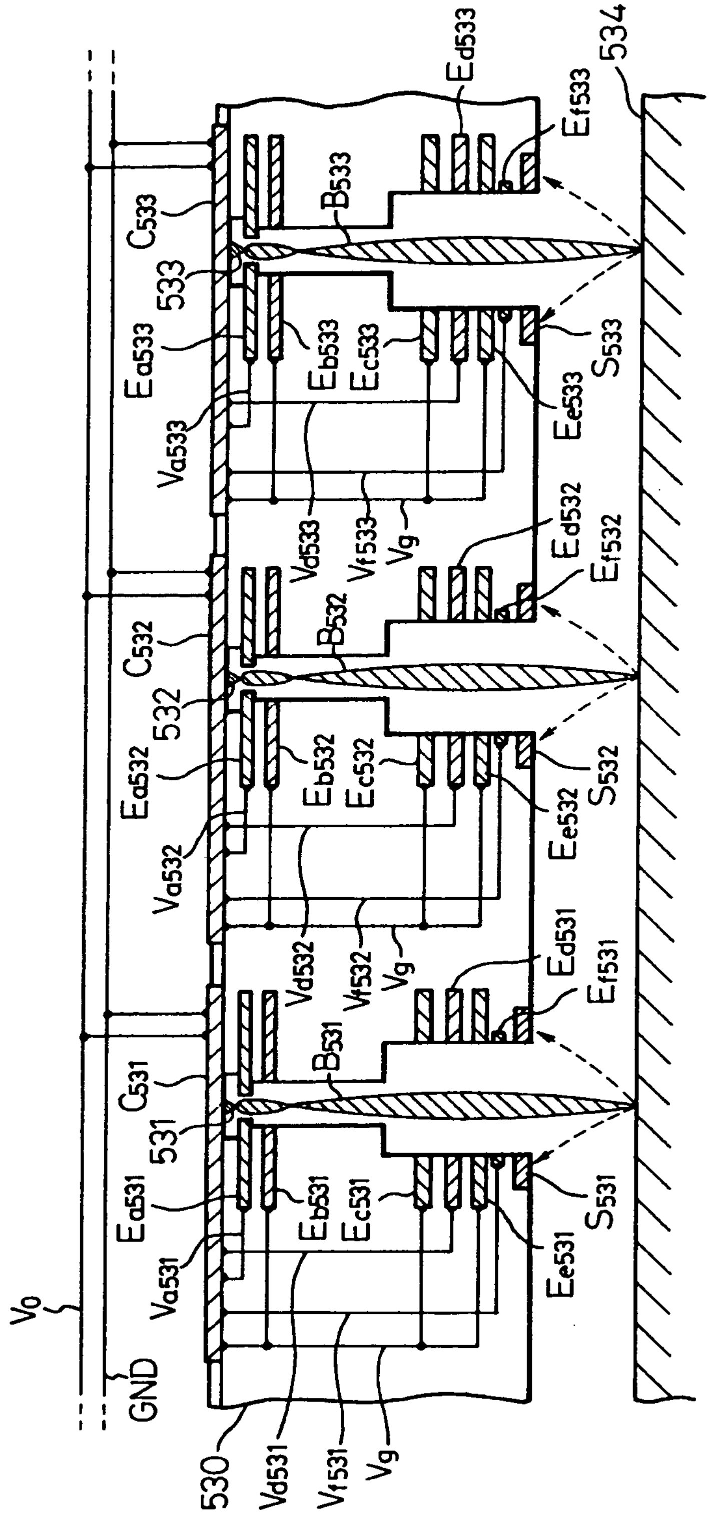

V0
GND
530
Vd531
Vf531
Vg
Va531
Ea531
Eb531
Ec531
Ee531
S531
531
C531
B531
Ed531
Ef531
Vd532
Vf532
Vg
Va532
Ea532
Eb532
Ec532
Ee532
S532
532
C532
B532
Ed532
Ef532
Vd533
Vf533
Vg
Va533
Ea533
Eb533
Ec533
Ee533
S533
533
C533
B533
Ed533
Ef533
534

Fig. 30(a)

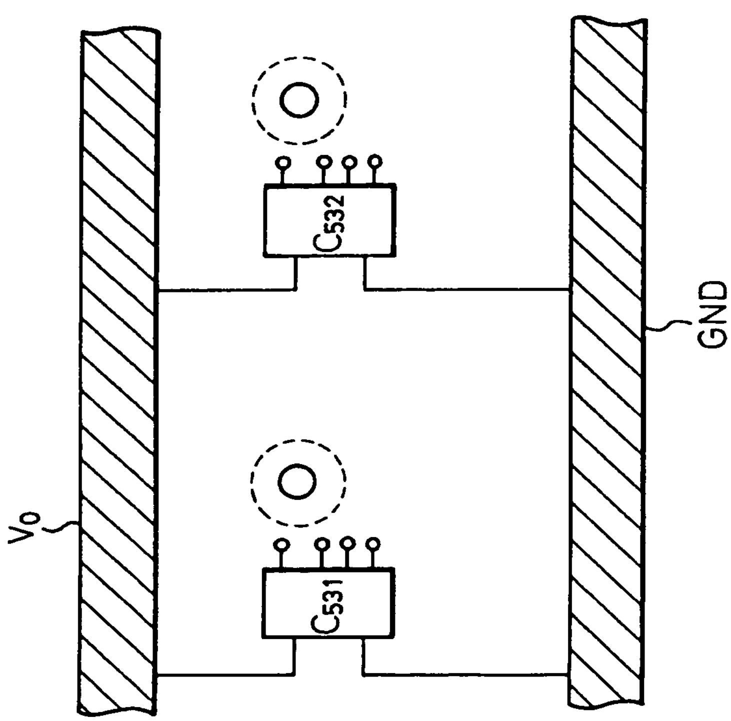


Fig. 30(b)

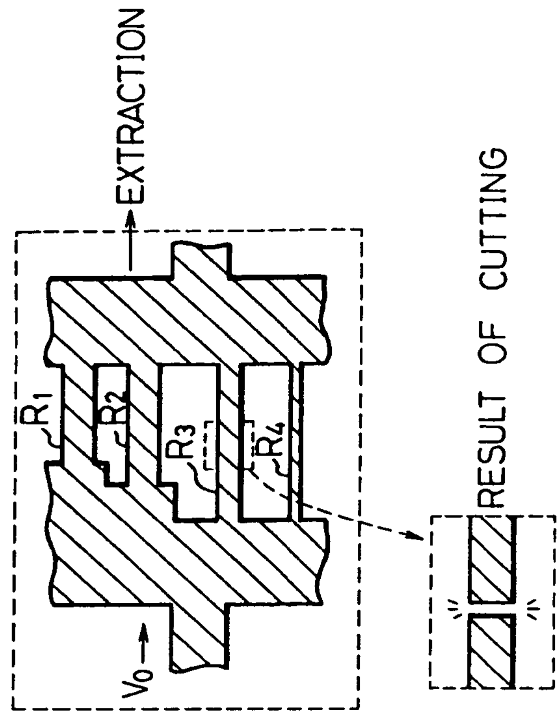


Fig. 31

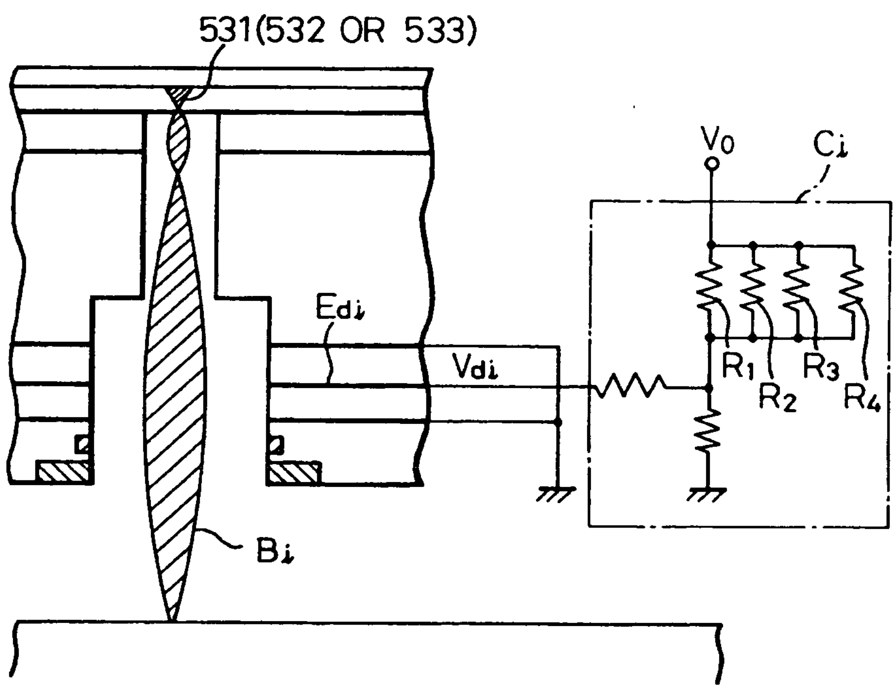


Fig. 32(a)

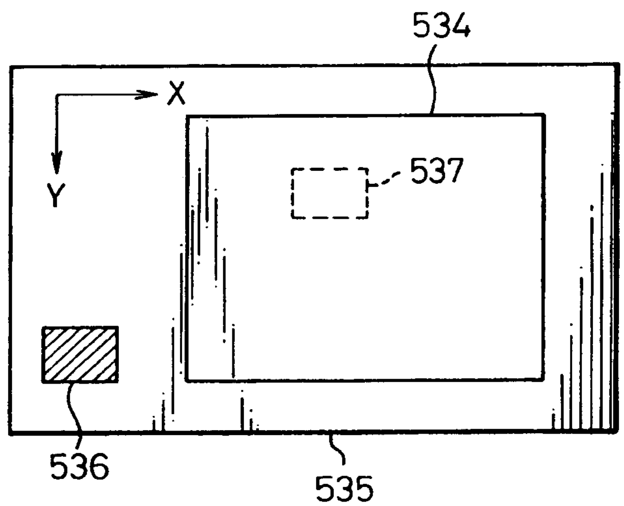


Fig. 32(b)

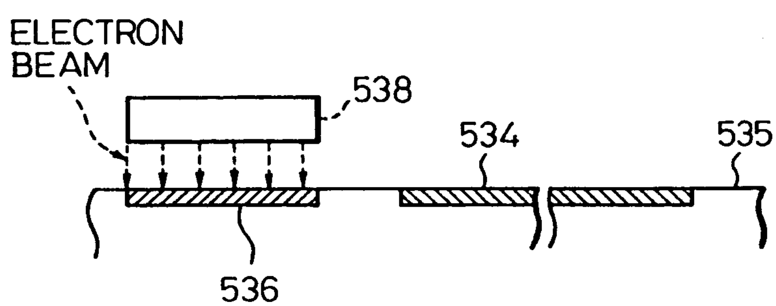


Fig.33(a)

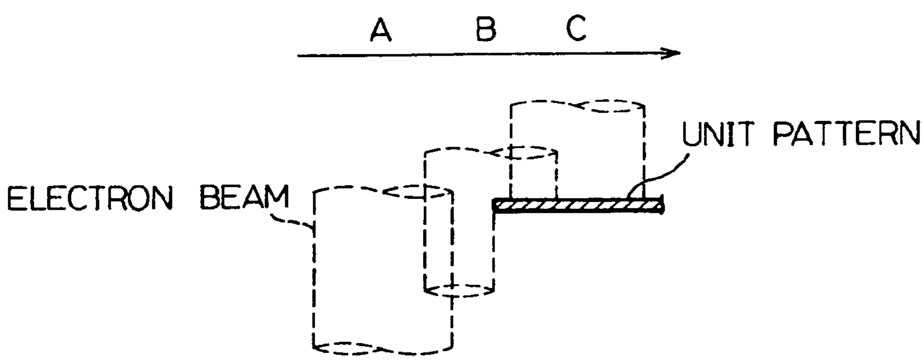


Fig.33(b)

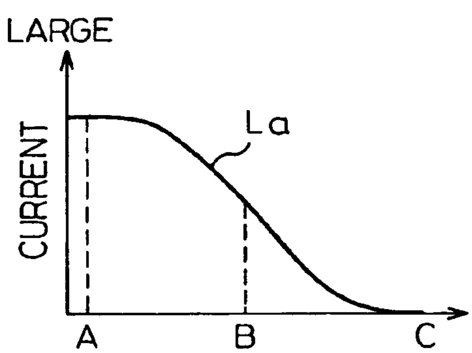


Fig.33(c)

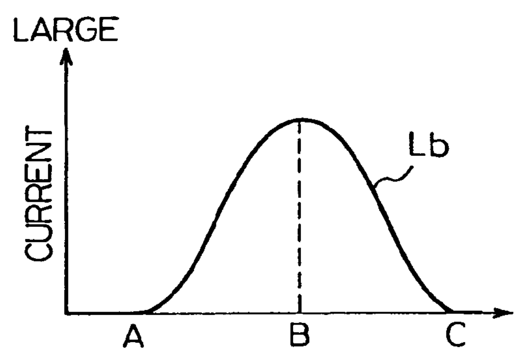


Fig.34(a)

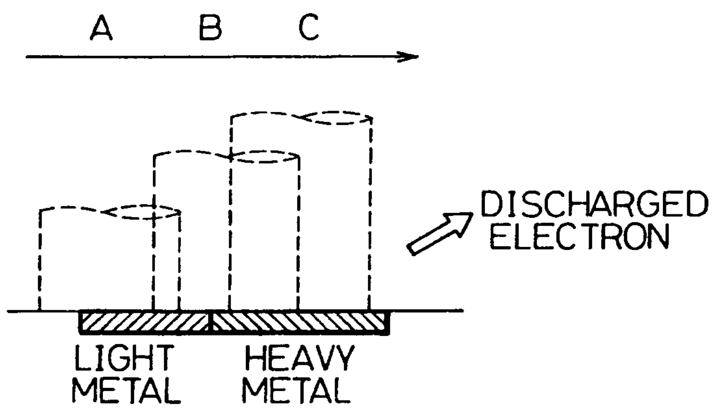


Fig.34(b)

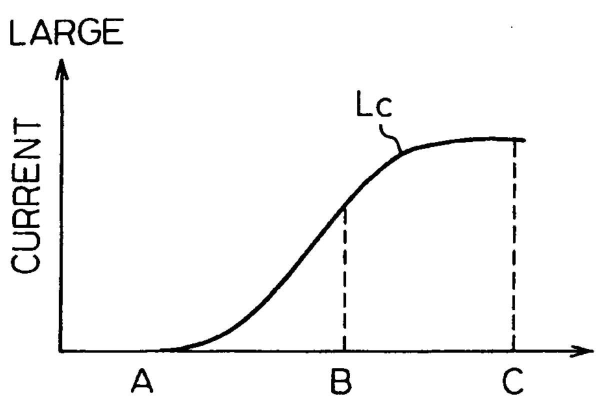


Fig. 35(a)

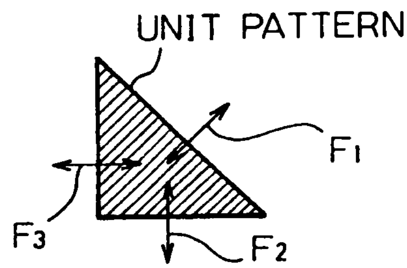


Fig. 35(b)

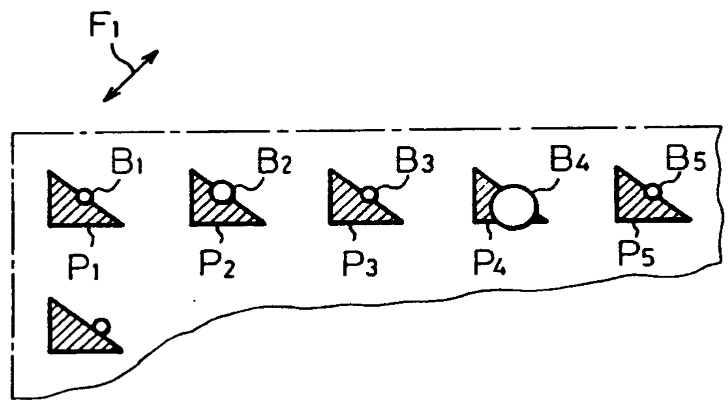


Fig. 35(c)

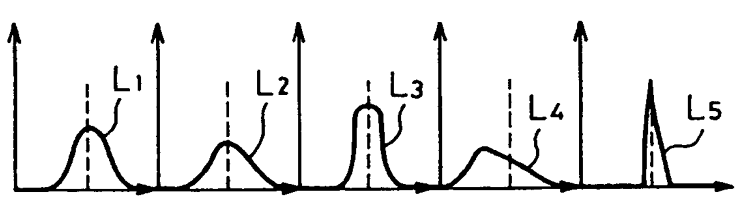


Fig.36

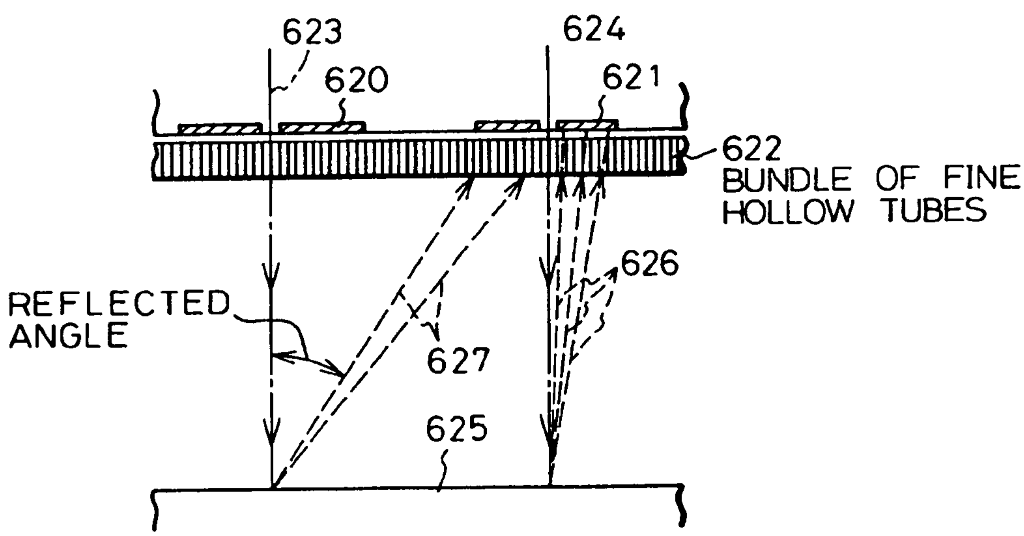

623
624
620
621
622
BUNDLE OF FINE HOLLOW TUBES
626
REFLECTED ANGLE
627
625

Fig.37

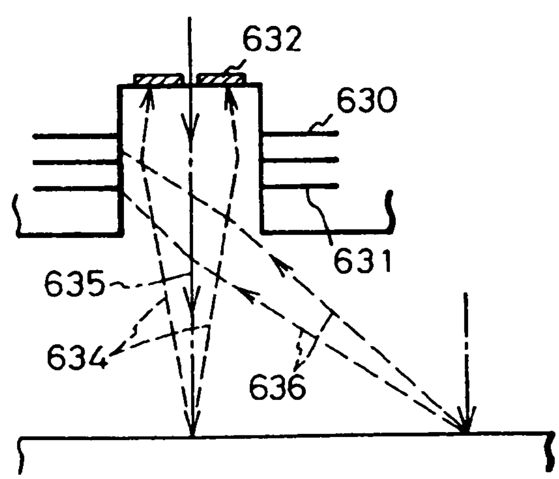

632
630
631
635
634
636

Fig. 38

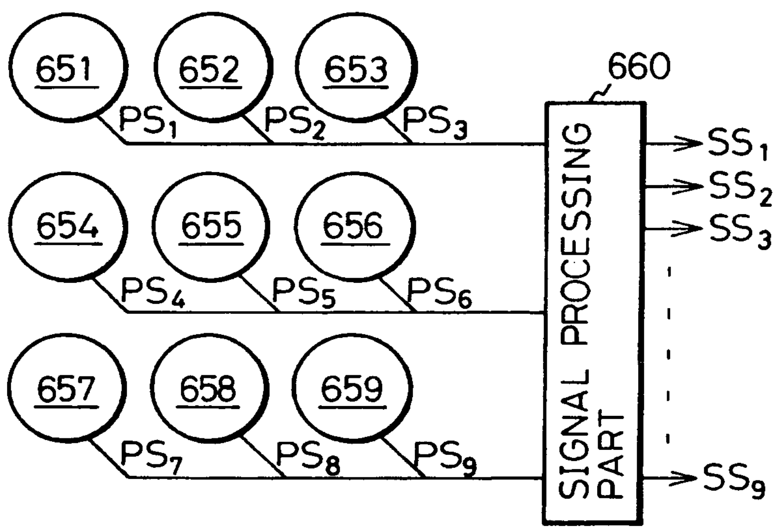

651
652
653
654
655
656
657
658
659
PS1
PS2
PS3
PS4
PS5
PS6
PS7
PS8
PS9
660
SIGNAL PROCESSING PART
SS1
SS2
SS3
SS9

Fig.39

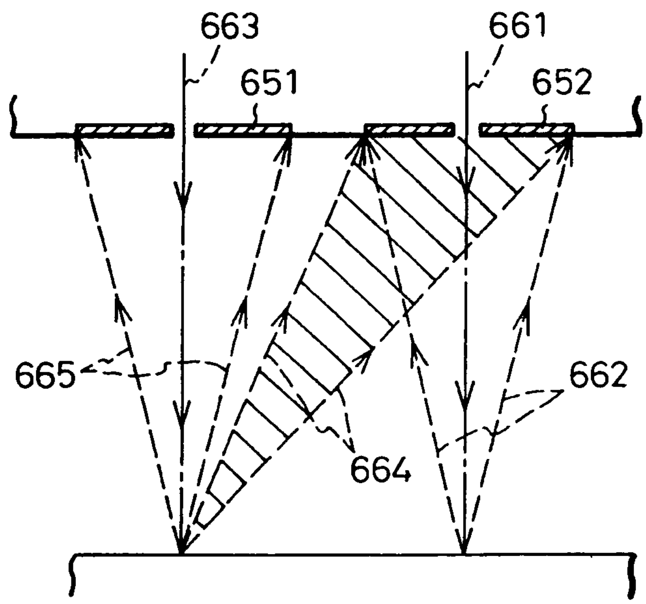


Fig.40(a)

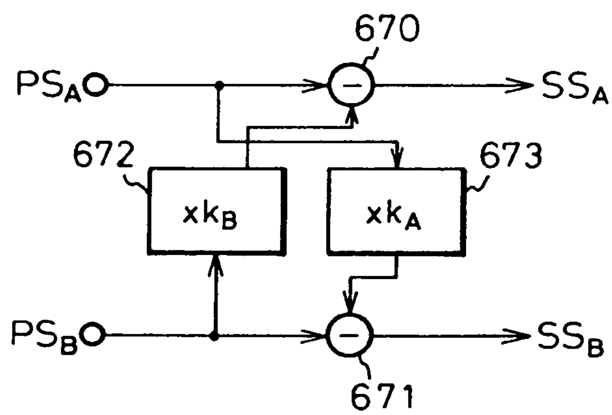


Fig.40(b)

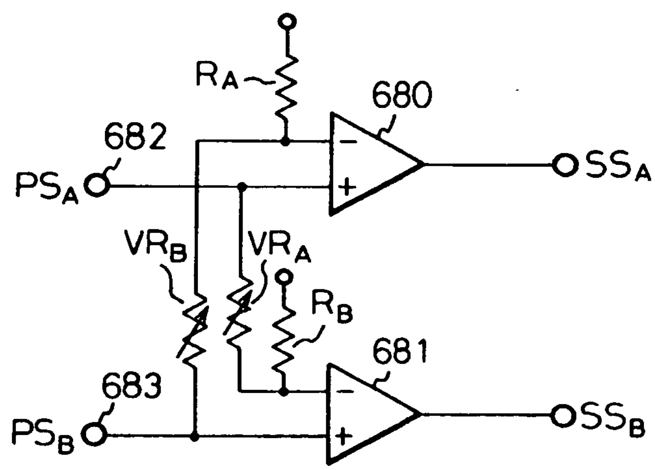


Fig.41

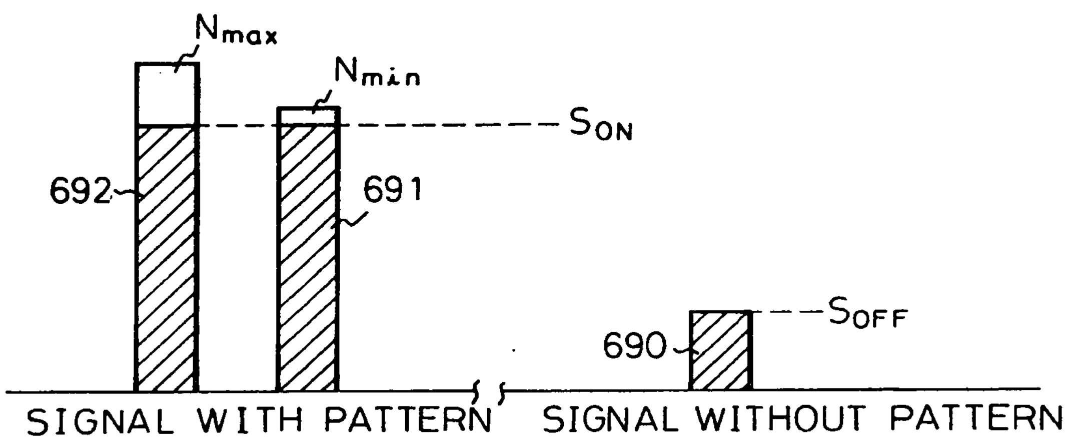

N_{max}
N_{min}
S_{ON}
692
691
S_{OFF}
690
SIGNAL WITH PATTERN
SIGNAL WITHOUT PATTERN

Fig.42(a)

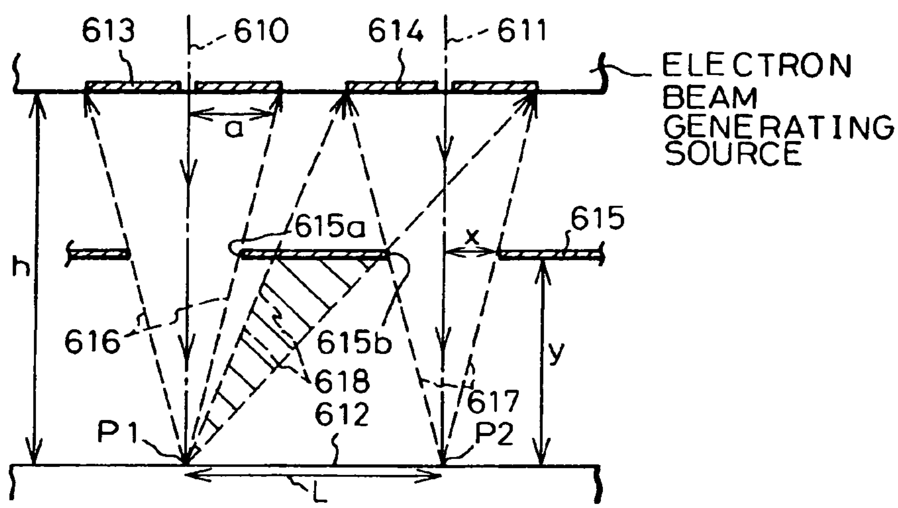


Fig.42(b)

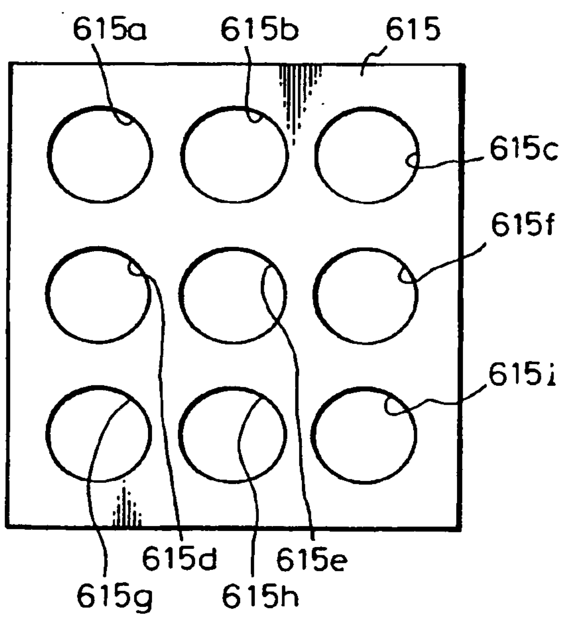


Fig.42(c)

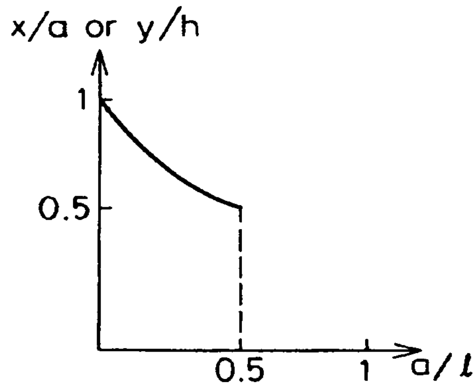


Fig.43(a)-1

Fig.43(a)-2

Fig.43(a)-3

Fig.43(b)

Fig.43(c)

Fig.43(d)

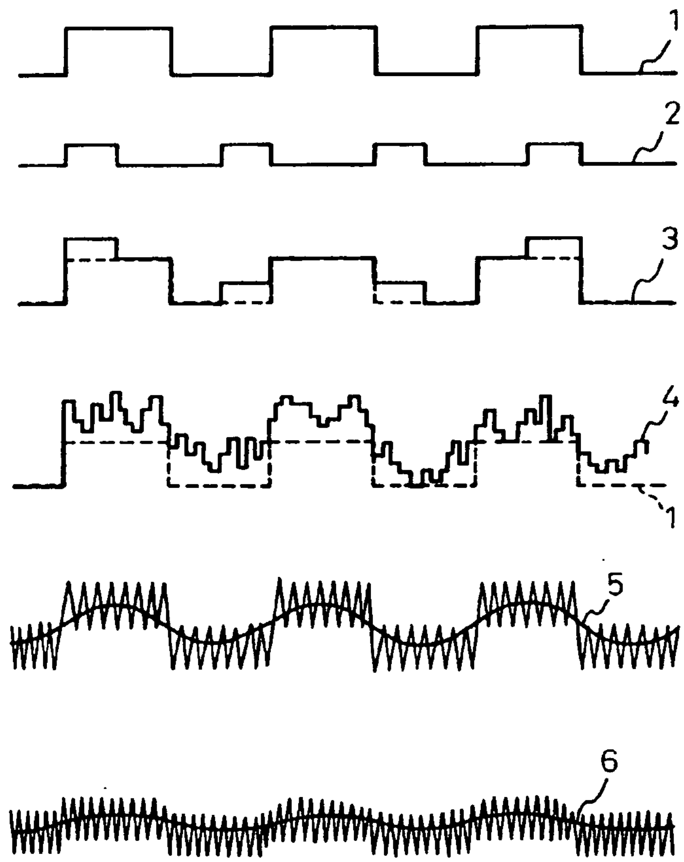


Fig.44

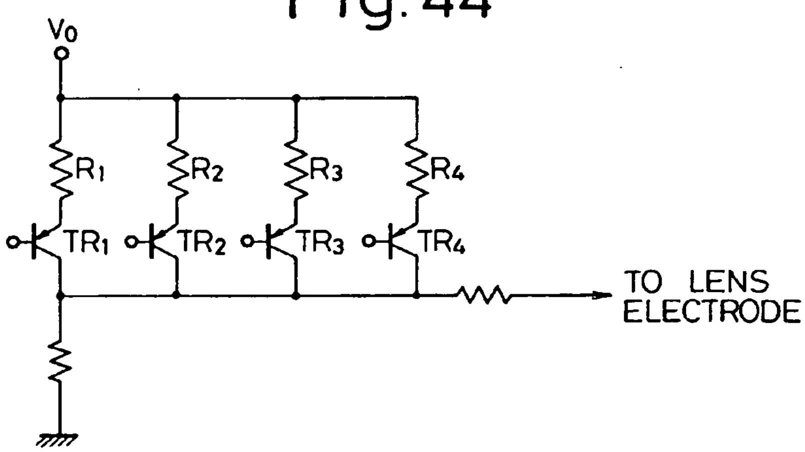


Fig. 45

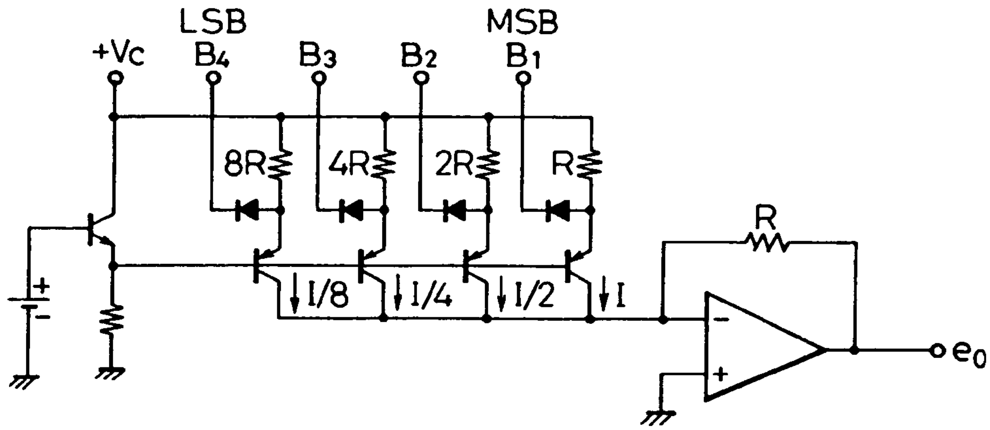
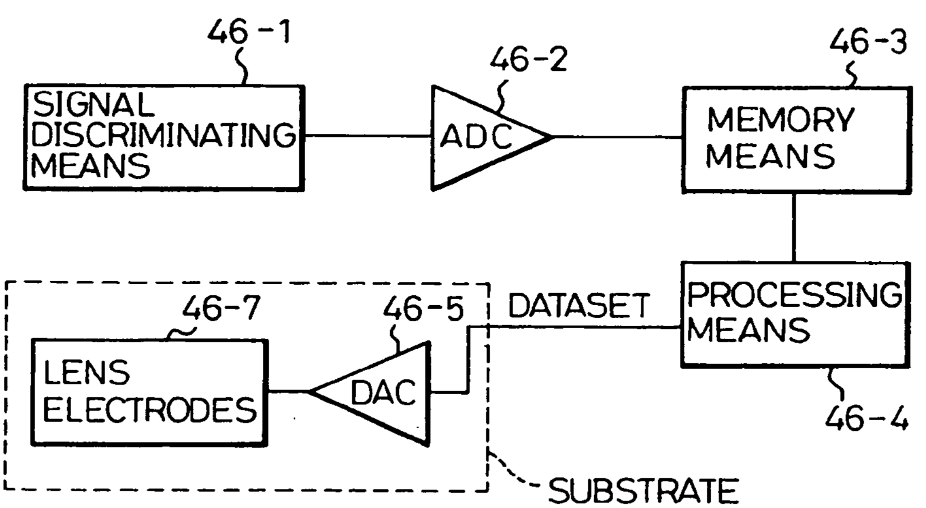

LSB
MSB
+Vc
B4
B3
B2
B1
8R
4R
2R
R
R
I/8
I/4
I/2
I
e0

Fig. 46


46-1
SIGNAL DISCRIMINATING MEANS
46-2
ADC
46-3
MEMORY MEANS
PROCESSING MEANS
46-4
DATASET
46-7
46-5
LENS ELECTRODES
DAC
SUBSTRATE

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 30 5311
Page 1

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 289 278 (CANON) * abstract * * column 1, line 5 - line 21 * * column 4, line 22 - column 5, line 27 * * column 7, line 59 - column 8, line 53; figures 1,2 * ---	1-4,6,8, 17-19, 23,27-35	H01J37/30 H01J37/305 H01J37/244
A	EP-A-0 339 951 (MICROELECTRONICS CENTER OF NORTH CAROLINA) * column 1, paragraph 1 * * column 1, line 37 - column 2, line 6 * * column 3, line 3 - column 4, line 27 * * column 8, line 54 - column 10, line 39; figures 1-2,7-10 * ---	1-3,17, 20,23, 27-35	
A	JOURNAL OF APPLIED PHYSICS. vol. 47, no. 12, December 1976, NEW YORK US pages 5248 - 5263; C.A. SPINDT ET AL.: 'PHYSICAL PROPERTIES OF THIN-FILM FIELD EMISSION CATHODES WITH MOLYBDENUM CONES' * abstract * * page 5248, right column, paragraph 2 - page 5250, left column, paragraph 3; figures 1-3 * ---	1,2,8, 20,23, 27-35	TECHNICAL FIELDS SEARCHED (Int. Cl.5) H01J
A	EP-A-0 379 865 (SIEMENS AG) * abstract * * column 1, line 5 - line 36 * * column 1, line 45 - column 2, line 37; figures 1,2 * ---	1,3,5, 23,27-35	
A	US-A-4 983 830 (IWASAKI) * column 1, line 6 - column 2, line 61 * * column 3, line 15 - column 4, line 6; figures 1-3 *	1,23-24, 27-35	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 SEPTEMBER 1992	GREISER N.

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Application Number

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	PATENT ABSTRACTS OF JAPAN vol. 8, no. 88 (E-240)(1525) 21 April 1984 & JP-A-59 006 537 (HITACHI) 13 January 1984 * abstract *	1,2,23, 27-35	
A	PATENT ABSTRACTS OF JAPAN vol. 8, no. 99 (E-243)10 May 1984 & JP-A-59 016 255 (NIPON DENSHIN DENWA) 27 January 1984 * abstract *	1,2,23, 27-35	
A	JOURNAL OF VACUUM SCIENCE AND TECHNOLOGY: PART B. vol. 4, no. 3, May 1986, NEW YORK US pages 686 - 691; K. SAITOH ET AL.: 'ELECTRON BEAM PATTERN INSPECTION SYSTEM USING IMAGE PROCESSING' * abstract * * page 686, left column, paragraph 1 - page 687, left column, paragraph 2 * * page 688, right column, paragraph 3 - page 690, right column, paragraph 2; figures 1,2,7-11 *	15-16, 21-22, 30,35	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	PATENT ABSTRACTS OF JAPAN vol. 6, no. 152 (P-134)12 August 1982 & JP-A-57 072 072 (FUJITSU) 6 May 1982 * abstract *	28,33	
A	FR-A-2 220 871 (NIHON DENSHI) * page 1, line 1 - line 3 * * page 7, line 18 - page 8, line 10; figures 7-10 *	6	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 SEPTEMBER 1992	GREISER N.

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